Independent Expert Review of Certain Girders Manufactured for the Rt. Hon. Herb Gray Parkway

Interim Report of Independent Expert Review Committee

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INTRODUCTION

At a preliminary estimated cost of $1.4 billion, the Rt. Hon. Herb Gray Parkway (formerly known as the Windsor-Essex Parkway) is currently one of the largest infrastructure construction projects in Canada. This Report is about certain prestressed concrete girders which were fabricated for use on that project.

On July 22, 2013, Hon. Glenn Murray, Ontario's Minister of Transportation and Infrastructure, issued the following public statement:

> *"I have become aware of an issue regarding some of the girders on the Rt. Hon Herb Gray Parkway.*
>
> *This is of great concern to me.*
>
> *Further installation of the girders in question has ceased. Other work on the project continues.*
>
> *I will be asking independent experts to look into the situation and advise the government within 30 days on the safety and durability of these girders, and to make recommendations.*

The girders in question will be removed unless the safety and durability can be assured and any compliance concerns are addressed.

Moving forward, I am working with the Ministries of Infrastructure and Transportation and Infrastructure Ontario management teams to review the administration of this contract and ensure the project company will fully comply with the contract and with the safety codes and standards.

I will also work with officials in reviewing how this contract was administered and to ensure we have a better process in place in the future.

The safety of Ontario's infrastructure is our top priority and we will ensure that the safety of the parkway is not compromised.

Windsor, and the whole Ontario economy, needs this project, which is creating jobs and will move goods and people quickly across the border."

The following is a brief outline of the events which led up to and which unfolded after the issuance of that public statement.

The Parkway Project, the Project Agreement, and the Players

Ontario's Ministry of Transportation ("**MTO**") is responsible for transportation infrastructure in the province, and, with its depth of technical expertise, has worked closely with Infrastructure Ontario to represent Ontario's interests in the delivery of the Rt. Hon. Herb Gray Parkway (the "**Parkway**") project[1].

Almost three years ago, on or about December 15, 2010, Ontario Infrastructure Projects Corporation[2] ("**I.O**.", also sometimes referred to as "**HMQ**"), as agent for Her Majesty the Queen in Right of Ontario as represented by the Minister of Infrastructure, entered into a design, build, finance and maintain concession agreement (the "**Project Agreement**") with Windsor Essex Mobility Group GP[3] ("**ProjectCo**") for a new parkway in Windsor, Ontario, as well as service roads, interchanges, landscaped parklands and recreational walking and cycling trails surrounding the Parkway.

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[1] The "Project Agreement", described and defined in this section, defines "MTO Activities" to include "*the provision of all governmental services and the conduct of all activities performed in or associated with Ontario roads and other services of a similar nature*"; and, similarly, other parts of the Project Agreement also reference "*MTO standards, guidelines and policies related to commissioning for highways*"

[2] A non-share capital corporation continued under the *Ontario Infrastructure Projects Corporation Act*, S.O. 2006, c. 9, Schedule I, as amended

[3] A general partnership formed under the laws of Ontario by its partners, Acciona WEP Holdings Inc., ACS WEP Holdings Inc. and Fluor WEP Holdings Inc.

Construction of the Parkway project commenced in 2011, and is expected to be open to traffic in late 2014.

The Parkway spans an 11-kilometre corridor, and, once completed, will include:

- a new six-lane below-grade freeway which is an extension of Highway 401;
- a separate, parallel four-lane at-grade service road network which is an extension of Highway 3;
- 300 acres of green space, which will eventually include 22 kilometres of recreational trails, ecological restoration sites and thousands of new native trees and vegetation; and
- 11 cut-and-cover tunnel sections, ranging from 120 to 240 metres in length, which are to be constructed with prestressed concrete girders (each of which has a length or span of approximately 30-35 metres), as well as a small number of land bridges which will also be constructed using the same type of girders.

The project will also eventually be extended to include a new international bridge, Canadian and U.S. immigration and inspection plazas, and an

interchange which will link Windsor to Detroit and connect Ontario's Highway 401 to the U.S. Interstate Highway System for the first time.

The Windsor-Detroit corridor is considered to be Canada's most important trade artery and the busiest commercial land border crossing in North America[4]. According to the Project Agreement, "(t)*he construction of the Parkway will have a positive impact on the entire Ontario economy by improving the movement of people, goods and services in a safe and efficient manner across the Canada/United States border at the Detroit and St. Clair Rivers*"[5].

The Project Agreement generally contemplates that, as concessionaire[6], ProjectCo would provide the design, construction, financing and maintenance of the Parkway, under a complex alternative financing and procurement model[7]. The organizational matrix for the model, which is intended to deal with the allocation, management or sharing of the project risk and

[4] In its August 9, 2013 presentation to the Independent Expert Review Committee ("**IER Committee**"), the MTO submitted that "*over one-third of Canada-U.S. road trade travels through this border crossing, with an average daily truck cargo of $298 million*" (see Exhibit D-1 of August 9, 2013 presentation by MTO to IER Committee, at page 3)

[5] Paragraph D of recitals to Project Agreement

[6] A concessionaire is typically a private sector firm (or firms) formed by one or more equity investors to design, build, finance and maintain a facility under an agreement with a public entity. The concessionaire team will also include key subcontractors, including the project designer, builder and operator, who may or may not be equity investors in the concessionaire team

[7] The alternative financing and procurement model is similar to a "public-private partnership" or "P3" model, which is typically funded and operated through a partnership of government and private sector companies, and which is becoming more commonplace in Canada and elsewhere for the design, construction and financing of major infrastructure projects, including public transit systems, airports, roads and highways, wastewater treatment plants, power projects, hospitals, schools, and jails

responsibility, is diagrammatically set out in **Schedule A** to this Report. It pictorially describes the complex web of contractual and other arrangements and relationships amongst parent, subsidiary and holding companies; equity and non-equity members; short-term and long-term lenders; financial and performance guarantors; designers and contractors; and the project's long-term operator[8]. The organizational diagram, however, does not disclose the myriad of design, construction management and other consultants and sub-consultants, subcontractors, labourers, material suppliers, fabricators, insurers, inspectors, certifying authorities, and other players.

The Birth of an Issue

A total of 935 of the 1,473 prestressed concrete girders required for the Parkway project were to be fabricated by Freyssinet Canada Limitée ("**Freyssinet**")[9], with the balance of 538 girders to be fabricated by another precaster, Prestressed Systems Incorporated (**"PSI"**)[10]. This Interim Report is intended to deal only with the girders fabricated by Freyssinet. A

[8] Under the terms of the Project Agreement, ProjectCo will undertake the operation, maintenance and rehabilitation of scheduled phases of the project, as each such phase is substantially completed, for a period of 30 years

[9] See Exhibit X-1 of the August 20-21, 2013 presentation by ProjectCo to IER Committee, at page 22; also see Transcript of the August 20, 2013 presentation by ProjectCo (per Philip Murray) to the IER Committee, at page 63, lines 12-17

[10] See Transcript of the August 20, 2013 presentation by ProjectCo (per Daniel Ruiz) to the IER Committee, at page 63, lines 18-20

Supplementary Report will be issued subsequently, which will deal with the girders fabricated by PSI. In terms of its Canadian experience, Freyssinet admitted that this was the first time it had fabricated prestressed concrete girders in Canada[11].

With respect to the Freyssinet plant, the first concrete for the girders was poured[12] on August 7, 2012, at which time the plant was in the process of attempting to qualify for its requisite Canadian Standards Association ("**CSA**") certification[13]. Girders fabricated at an *un*certified plant are not permitted to bear the standard-setting CSA certification mark[14]. Certification of the plant had been held up due to Freyssinet's failure to comply with 13 items on CSA's Certification Program Checklist[15]. However, despite there being no CSA certification at the time, Freyssinet continued to produce the girders, and, between August 7 and November 19, 2012, a total of 203 girders

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[11] Transcript of the August 28, 2013 presentation by Freyssinet (per Franck Chavent, Canadian Operations Manager) to IER Committee, at page 5, line 15 to page 6, line 10

[12] That is, for girders A1, A2 and A3 for Tunnel T7, according to an August 21, 2013 e-mail from counsel for ProjectCo to the IER Committee

[13] The Canadian Standards Association ("**CSA**") is the certifying authority responsible for quality control/assurance of the Freyssinet plant. CSA's form of Product Service Agreement may be found at Tab 9 of Document Brief No. 3 of the August 20-21, 2013 presentation by ProjectCo to IER Committee

[14] Ontario Provincial Standard Specification OPSS 909.07.02 provides that "*Members* [defined in 909.03 to mean "*a precast concrete prestressed girder*"] *shall be fabricated by a plant certified by the Canadian Standards Association (CSA) or Canadian Precast/Prestressed Concrete Institute (CPCI) according to CAN/CSA – A23.4 under the category: Precast Concrete Products–Structural, Prestressed*"

[15] See Tab 42 of the Documents Binder submitted at the August 20-21, 2013 presentation by ProjectCo to IER Committee

were fabricated[16]. 50 of those 203 girders were erected for use in Tunnel 2, in circumstances where the concrete deck, topsoil and landscaping on the top of that tunnel had mostly been completed[17], and the other 153 girders produced during that period were either installed on Tunnel 7, without connections and without being topped by a concrete deck or topsoil, or were otherwise earmarked for Tunnel 7 but stored off-site in the Freyssinet yard[18].

The Freyssinet plant finally achieved CSA certification on November 19, 2012. By letter dated November 20, 2012, Demtew Tesfaye, (Engineer, Construction Programs) of the CSA Group wrote to Javier Gonzalo of Freyssinet in order to confirm that the CSA Group had issued its CSA certification the previous day[19]. The letter continued:

> *"I would also confirm that products that have been completed between our audit date of August 7, 2012 to current, upon review and acceptance and*

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[16] Transcript of the August 13, 2013 presentation by I.O. (per Tom Woods, Contracts Director, Highways Group) to the IER Committee, at page 54, lines 18-19; and Exhibit X-6 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee

[17] In the presentations to the IER Committee, a differentiation had been made between girders which had been "*stored in place*" (i.e., situated on top of piers and abutments, but without connections and without a concrete deck topping), and girders which were "*installed on site*" (i.e., a more permanent installation, with a concrete deck, and with one metre of topsoil and landscaping on top). According to the girder layout drawing for Tunnel T2 (i.e., Exhibit X-7 of the August 20-21, 2013 presentation of ProjectCo to the IER Committee), the concrete deck had been poured over 134 girders (i.e., 67 North and 67 South), but had not as yet been poured over the remaining 26 girders (i.e., South Side #68-80 and North Span #68-80).

[18] Exhibit X-6 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee

[19] Transcript of the August 9, 2013 presentation of MTO to the IER Committee, art page 155, line 20 to page 156, line 3

> *signing of statement of compliance by the retained engineer and the Quality Manager indicating that products have been manufactured in meeting with the project specifications and CSA Std. A23.4 requirements would be acceptable and could bear the certification mark."*

The actual Certificate of Qualification, however, contained no explicit reference to CSA's retroactive determination that girders fabricated prior to November 19, 2012 would be entitled to bear the CSA certification mark.

The *ex post facto* certification of the Freyssinet plant by CSA appeared at the time to resolve the issue regarding the use of the CSA mark on the Freyssinet girders which were to be fabricated *after* November 19, 2012; and indeed Freyssinet continued to fabricate girders until May 23 or 24, 2013[20], having produced a total of 500 girders by that time.

However, the question remained, to be addressed at a later date, as to whether the girders fabricated between August 7 and November 19, 2012,

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[20] Transcript of the August 13, 2013 presentation by I.O. (per Tom Woods, Contracts Director, Highways Group) to the IER Committee, at page 51, line 24; also see letter from Parkway Infrastructure Constructors (the construction component of the ProjectCo consortium) to WEMG (the contracting party for ProjectCo) dated July 19, 2013 (Tab 83 of Exhibit A-1 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee

when the plant was not CSA-certified[21], had achieved the requisite standards of safety and durability.

Furthermore, apparently unbeknownst to I.O. and MTO at the time of the CSA certification on November 19, 2012, there was another lurking issue which would soon emerge – the use of tack welding to hold together the cages containing welded wire reinforcing mats[22] – which would also affect I.O.'s and MTO's views of the Freyssinet girders. As discussed below, the Canadian Highway Bridge Design Code (CSA S6-2006) ("**CHBDC**") provides that tack welding of reinforcing steel is not permitted, unless it has been approved by a "*Regulatory Authority*", in this case, MTO[23]. And, as will be seen below, the Freyssinet welders used tack welds when assembling the

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[21] By letter dated November 27, 2012, I.O advised ProjectCo that "*HMQ does not consider NU girders manufactured prior to the plant certification date of November 19, 2012 to be compliant with the PA requirements and accordingly not acceptable for use on the project*" – see Tab 4 of correspondence binder submitted to the IER Committee at the August 9, 2013 presentation by MTO

[22] Tack welding is used for the purpose of assembling the reinforcing cage so that it is easier to move the cage into the steel forms before the concrete is poured

[23] Section 8.5.3.1(c) of the CHBDC (CAN/CSA-S6-06) provides that "(u)*nless otherwise Approved, tack welding of reinforcing bars shall not be permitted*"; section 1.3.2 defines "*Approved*" to mean "*approved in writing by the Regulatory Authority*", and "*Regulatory Authority*" is defined to mean "*the federal, provincial, or territorial Minister having governmental jurisdiction and control, his or her nominee, or the local authority to whom this authority is delegated*" (in this case, MTO). Although the CHBDC is an industry Code, it is in fact legislatively mandated. Section 2(1) of Ontario Regulation 104/97 of Ontario's *Public Transportation and Highway Improvement Act*, which O.Reg. deals with "*Standards for Bridges*", provides at section 2(1)(a) that "(w)*here any person undertakes or causes to be undertaken the design, evaluation, construction or rehabilitation of a bridge, the design, evaluation, construction or rehabilitation shall conform to the standards set out in the Canadian Highway Bridge Design Code*"

reinforced steel cages for the girders, without Freyssinet having obtained the requisite prior approval[24] by MTO.

The Fabrication, Erection and Storage of the Freyssinet Girders

The following information was provided to the Independent Expert Review Committee ("**IER Committee**") with respect to the fabrication, erection and storage of the Freyssinet girders:

[24] According to Robert Milne of Acuren (ProjectCo's testing company), a "*Regulatory Authority*" such as MTO "*would want to know what the materials were to make sure they were weldable without any sort of special precautions. They would* [also] *want to know that the welders were qualified*" (see Transcript of September 17, 2013 presentation by ProjectCo (per Robert Milne) to the IER Committee, at page 234, line 9*ff*. Code clauses with conditionality invariably mean that approval may be granted subject to certain requirements being met. Until the requirements have been met, approval may not be granted, so retroactivity to a conditional approval is never conceded. Examples of such requirement for pre-approval are also found in the legislation and industry standards of other jurisdictions (e.g., see "Ministry of Transport U.K. Highways Agency – Design Manual for Roads and Bridges, Vol. 1, Sec. 3 BA40/93 – Tack Welding of Reinforcing Bars", where tack welding approval is conditional upon the contractor demonstrating to the engineer that the fatigue life, durability and other properties of the concrete member are not adversely affected by the welding.

TUNNEL NUMBER	TOTAL NUMBER OF FABRICATED GIRDERS (AUG. 7/12 – MAY 24/13)	TOTAL NUMBER OF FABRICATED GIRDERS (AUG. 7/12 – NOV. 19/12)	GIRDERS INSTALLED ON SITE (WITH CONNECTIONS AND CONCRETE DECK)	GIRDERS INSTALLED ON SITE (WITHOUT CONNECTIONS OR CONCRETE DECK)	GIRDERS STORED OFF-SITE
T2	**160**[25]	**50**	**160**[26]	**0**	**0**
T3	**72**[27]	**0**	**0**	**0**	**72**
T5	**104**[28]	**0**	**0**	**24**[29]	**80**
T7	**164**[30]	**153**	**0**	**104**[31]	**60**
TOTAL:	**500**	**203**	**160**	**128**	**212**

I.O.'s Concern Regarding the CSA Audit of the Freyssinet Plant

I.O. was apparently concerned about the CSA audit at the Freyssinet plant for the period between August 7 and November 19, 212, and wanted to see "*whether* [I.O.] *could be satisfied that there was a quality management system in place that was the equivalent of a CSA-certified quality management system*"[32]. As a result, a meeting of representatives of the Ministry of Transportation, I.O., Freyssinet and ProjectCo was held at the CSA offices on December 20, 2012.

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[25] See Exhibit X-1 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee, at pages 30 and 34

[26] See footnote 17, *supra*

[27] See Exhibit X-1 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee, at pages 31 and 34

[28] *Ibid.* at pages 32 and 34

[29] *Ibid.*

[30] *Ibid.* at pages 33 and 34

[31] *Ibid.*

[32] Transcript of the August 13, 2013 presentation by I.O. (per Tom Woods, Contracts Director, Highways Group) to the IER Committee, at page 59, lines 3-6

At the recent I.O. presentation to the IER Committee, Tom Woods, Contracts Director (Highway Group) of I.O., stated that "[December 20, 2012] *was the first opportunity we* [I.O.] *had to actually see hard copy of the CSA's audit and audit findings from August 2nd*"[33].

Tom Woods continued:

> "*At that* [December 20, 2012] *meeting, one of the nonconformances noted was that the workers were not certified to W186, the reinforcing steel welding standard from CSA. It was noted that all of these welders were trained welders. They were all trained to A47.1, the structural steel standard, just not the reinforcing steel standard. There was a comment made in the CSA audit regarding the use of tack welding. It was noted that some of the bars were undercut and some of the tack welds appeared to be of poor quality*"[34].

In this regard, Tom Woods stated that "*this was the first time that anyone heard or noted that tack welds were being used in this plant*"[35].

The story from Tom Woods continued to unfold:

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[33] *Ibid.* at page 59, lines 8-12
[34] *Ibid.* at page 59, line 16 to page 60, line 3
[35] *Ibid.* at page 60, lines 6-8

> *"On January 28th 2013, MTO informed IO that the use of these tack welds in this way was a CHBDC code noncompliance. That is when IO was told this is a code noncompliance and we started to take the steps within our project agreement to figure out what that means.*[36]
>
> . . .
>
> *"The very first thing we did was February 7th we issued a strongly-worded letter to Project Company that listed the details of the problems that we thought were present in these girders."*[37]

From December 20, 2012 onward, there followed a series of discussions at various meetings and sessions, teleconferences, and an intense exchange of e-mail and regular correspondence amongst MTO, I.O. and ProjectCo regarding compliance and CSA certification issues, all in an attempt to find a commercial and technical solution. Explanations were demanded, positions were taken, proposals were made and revised, a visit was made to the Freyssinet plant by representatives of MTO and I.O., work stopped and started with respect to the concrete deck pour on Tunnel T2, and eventually a Notice of Dispute under the Project Agreement was issued by I.O. on May 14,

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[36] *Ibid.* at page 61, lines 16-21
[37] *Ibid.* at page 62, lines 1-5

2013. This was followed by further teleconferences, further proposals, and the issuance of updated technical memos. By mid-June, the parties had begun discussing the terms of a draft, "*without prejudice*" 11-point plan to attempt to address the issues and MTO's and I.O.'s concerns[38]. On June 17, 2013, the issues escalated to the Minister's office, and the 11-point plan was put in abeyance. On June 21, 2013, ProjectCo issued a notice that it intended to complete the concrete deck pour on Tunnel T2; and on June 22, I.O. issued a stop-work order.

On July 22, 2013, the Minister of Transportation and Infrastructure issued a public statement (quoted at pages 5-6 above) regarding the use of non-compliant girders on the Parkway project, indicating that an Independent Expert Review Committee would be appointed to review the safety and durability of the affected girders.

The Independent Expert Review Committee and its Terms of Reference

As stated above, Hon. Glenn Murray, Ontario's Minister of Transportation and Infrastructure, appointed an Independent Expert Review Committee to assess the safety, durability, quality and performance of certain prestressed

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[38] See letter from I.O. to ProjectCo dated May 31, 2013, at Tab 74 of Exhibit A-1 of the August 13, 2013 presentation by I.O. to the IER Committee, and ProjectCo's letters of reply dated June 7 and 16, 2013 (Tabs 76 and 78 of Exhibit A-1, respectively)

concrete girders containing tack-welded reinforcing steel. Part of the review was intended to evaluate the girders' compliance with all applicable legislation, regulations, codes, and industry standards, as well as the quality control/assurance and certification requirements relating to their fabrication.

The IER Committee is chaired by Harvey J. Kirsh, a recognized authority in construction law who has had 40 years of experience in the litigation, arbitration and mediation of complex construction claims and disputes arising out of significant infrastructure, energy, resource, industrial, commercial, and institutional projects, both domestically and internationally. In addition to its Chair, the Committee consists of the following group of distinguished and preeminent Canadian structural engineers:

- Dr. Husham Almansour, a research associate with the National Research Council Institute for Research in Construction, who is an adjunct professor in structural engineering at the Ottawa-Carleton Institute of Civil Engineering, and who has had 25 years of experience in structural design, modeling and testing, with a focus on bridge structures;

- Carlos Laborde-Basto, an engineer and principal of Laborde and Associates. During his career, he has supported project teams, conducted structure condition surveys and evaluations, and provided direction for rehabilitation and special studies on structures. He has been involved as a specialist and project manager in numerous provincial and municipal road and bridge projects. He has participated in various provincial standards committees, and bridge design and international code committees;

- Dr. Shamim Sheikh, a professor of civil engineering at the University of Toronto. Among his many awards is the American Concrete Institute Structural Research Award for outstanding contributions to the application of structural engineering research and for notable achievement in research in structural engineering. Currently, Dr. Sheikh chairs Committee S16 of the Canadian Highway Bridge Design Code (CHBDC) on fibre-reinforced structures and is a member of the CHBDC Committee; and

- Dr. Dagmar Svecova is a professor in the department of civil engineering at the University of Manitoba, with research interests in the field of structural engineering including reinforced and prestressed

concrete structures. Dr. Svecova is a member of the American Concrete Institute and the Canadian Society of Civil Engineers and is director of the Intelligent Sensing for Innovative Structures Canada Resource Centre.

The abbreviated professional biographies of the members of the IER Committee are set out in **Schedule B** to this Report.

Furthermore, the Terms of Reference for the Independent Expert Review are annexed as **Schedule C** to this Report. As noted in that document, the IER Committee:

- will independently review the engineering and construction issues related to the fabrication and installation of certain prestressed concrete girders;
- will apply professional engineering practices and standards, and will offer its independent and objective advice relating to its mandate;
- will have compete operational and intellectual independence in the performance of its mandate and in the preparation of its Report,

through independent research, consultations and dialogue among interested parties; and

- will perform its duties without making any findings of fault in relation to misconduct, and without expressing any conclusions or recommendations regarding issues that may arise in a potential legal proceeding.

It is intended that the review process and its results are generally to be transparent, with the exception that (a) legal advice, (b) deliberations of the IER Committee members, and (c) documents or information provided by ProjectCo, which are expressly identified as being confidential or commercially sensitive, shall not be divulged, except as may be required by law.

Presentations and Submissions to the IER Committee

The following parties made presentations to, or participated in review sessions with, the IER Committee:

<u>August 9, 2013</u>: presentation by representatives of MTO;

August 13, 2013: presentation by representatives of I.O. (including its General Counsel and representatives of its engineering consultant, C2HM Hill);

August 20 and 21, 2013: presentation by representatives of ProjectCo (including its individual engineering consultants, Professor Dr. Hugo Corres Peiretti (of FHECOR Ingenieros Consultores) and Raymond H. R. Tide (of Wiss, Janney, Elstner Associates, Inc.); representatives of its design consultant for the Parkway project, Hatch Mott MacDonald; external counsel for ProjectCo; and General Counsel for several of the companies which comprise or are affiliated with the ProjectCo consortium, namely Fluor Corporation, Acciona Infrastructure Canada Inc., Dragados Canada, Inc., and ACS Infrastructure Canada Inc.);

August 28, 2013: review session with representatives of Freyssinet Canada Limitée and Freyssinet International Company;

August 28, 2013: review session with Scott Griffin of GS Inspection Consultants, Inc.[39];

August 28, 2013: review session with Ken Kapusniak of HGS Limited[40];

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39 Scott Griffin, a graduate engineer, inspected the girders at the Freyssinet plant on August 2, 3, 7 and 8, 2012

September 16, 2013: teleconference review session with Micheal Reeve (former employee of Freyssinet);

September 16, 2013: review session with representatives of CSA;

September 17, 2013: presentation by representatives of ProjectCo (including a representative of its testing company, Acuren; individual engineering consultant, Raymond H. R. Tide (of Wiss, Janney, Elstner Associates, Inc.); representatives of its design consultant for the Parkway project, Hatch Mott MacDonald; external counsel for ProjectCo; and General Counsel for several of the companies which comprise or are affiliated with the ProjectCo consortium, namely Fluor Corporation, Acciona Infrastructure Canada Inc., Dragados Canada, Inc., and ACS Infrastructure Canada Inc.).

Included in the correspondence and reports set out in the presentation materials submitted by ProjectCo to the IER Committee were correspondence from Dr. Maher K. Tadros[41] and a report prepared for ProjectCo by Professor

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[40] Ken Kapusniak is a P.E. (U.S.) and a P.Eng. (Ont.), but is not a structural engineer. The shop drawings for the Freyssinet girders were prepared by the structural engineering firm, e.Construct USA.LLC, and were sealed by Ken Kapusniak's company, HGS Limited. Ken Kapusniak was an independent Quality Verification Engineer (QVE) for Freyssinet from August 7 to November 19, 2012, and was appointed on November 19, 2012 to act as "Retained Engineer" for the CSA certification of the Freyssinet plant (see Transcript of the August 28, 2013 presentation of Ken Kapusniak to the IER Committee, from page 63, line 5 to page 64, line 21)

[41] See correspondence from Dr. Maher K. Tadros to either Tierra Armada Company (a company related to Freyssinet) or Freyssinet dated January 17, 2013, February 18, 2013, April 22, 2013, May 8, 2013, and May 15, 2013 (see Tabs B4, B5, B7, B14 and B16 of Document Brief No. 1 of the August 20-21, 2013

Michael Collins[42]. Since the IER Committee did not meet directly with them, it advised ProjectCo that it was prepared to receive supplementary memos from Dr. Tadros and Professor Collins, although none were in fact subsequently submitted.

The IER Committee also followed up on undertakings, given by the presenters, who participated in the review process, to provide additional information and documents. In this regard, the Committee has received selected supplementary information and documentation from several presenters.

Deconstructive testing of sample girders was conducted by ProjectCo Although the guidelines or terms of reference were not provided to the Committee, the Committee assumes that the testing was undertaken for the purpose of observing and verifying, among other things, tack welding spacing; the tensile strength of steel reinforcement affected by tack welds; and the concrete properties as required by specification and concrete performance

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presentation by ProjectCo to IER Committee); also see Exhibit X-1 of August 20-21, 2013 presentation by ProjectCo to IER Committee, at pages 101-109

42 Michael P. Collins and Evan Bentz, "*Evaluation of Shear Capacity of Pretensioned Prestressed Concrete Bridge Girders with Tack Welded Stirrups*", dated August 18, 2013 (see Tab B27 of Document Brief No. 1 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee)

indicators associated with long term durability, strength, and serviceability of the girders.

Consistent with the transparency of the independent expert review process, the parties who participated in the independent expert review process were also provided with copies of the transcripts of all of the presentations and review sessions, and were given the opportunity to make submissions for the correction of any factual errors, omissions or discrepancies in those transcripts. The IER Committee has observed that the presenters took full advantage of this process of purporting to correct "factual" errors in the transcripts of other presenters.

The IER Committee was also pleased to observe that ProjectCo and Freyssinet, in their respective presentations, committed to provide full cooperation and complete transparency[43].

[43] See Transcript of the August 20, 2013 presentation by ProjectCo to the IER Committee, at page 4, lines 6-9 (per Ignacio Lasa); page 6, lines 11-12 (per Bruce Reynolds); page 6, line 25 to page 7, line 1 (per Bruce Reynolds); page 7, line 5 to page 8, line 15 (per Bruce Reynolds); page 21, line 8 to page 22, line 8 (per Bruce Reynolds); and see Transcript of the August 21, 2013 presentation by ProjectCo to the IER Committee, at page 115, lines 3-4 (per Bruce Reynolds), page 174, lines 2-4 (per Bruce Reynolds); also see Transcript of the August 28, 2013 presentation by Freyssinet to the IER Committee, at page 2, lines 21-22 (per André Coudret); page 72, lines 20-23 (per Franck Chavent); page 86, lines 7-17 (per Franck Chavent); page 119, lines 14-23 (per Franck Chavent)

CSA CERTIFICATION OF FREYSSINET PLANT

The Need for Standards

A "standard" is an agreed, repeatable way of doing something. It is a published document that contains technical specifications or other precise criteria designed to be used consistently as a rule, guideline, or definition. Standards aim to increase the reliability and the effectiveness of many products, goods and services. Any standard is a collective work. Committees of manufacturers, experts, research organizations, government departments and users bring together their experience and expertise to draw up standards that evolve to meet the demands of the society and technology, of a particular material, product, process or service.

The ability to demonstrate compliance with widely recognized and respected standards is an effective means of seeking acceptance and of differentiation in a competitive marketplace.

CSA develops various design and engineering standards that address safety, energy efficiency, sustainability and durability. Industry associations as well as building and infrastructure owners use CSA standards to help ensure safety, improve efficiency in design, manufacturing and construction and to

help manage risk. Standards are developed by consensus through rigorous peer reviews, public reviews and balanced committees representing diverse stakeholders, and are widely referenced by specification writers, regulators, policymakers, inspectors and professional associations.

Industries and governments rely on our experts to manage and reduce impacts on the environment through energy efficiency, water conservation and re-use, Environmental Product Declarations, Product Category Rules and sustainable design. Engineers are accredited in the U.S. and Canada to develop standards in a wide range of subject areas that speak to product safety and performance, process improvement, best practices and safer work environments. We play an active role in international standards development and harmonization initiatives in order to help apply more uniform construction requirements across North America.

Customers seek independent verification for products that technical standards provide. Certification marks earned by businesses whose products and practices consistently stand up to rigorous examination are instantly recognizable and act as respected badges of quality, safety and performance.

CSA operates all its programs under a signed Product Service Agreement ("**PSA**"). CSA products must be manufactured in accordance with the relevant PSA and all applicable standards. Products that are found to deviate from any applicable standards cannot bear the CSA certification mark[44] .

Facts

On January 20, 2012, Freyssinet met CSA to discuss the certification process of the new plant for the production of precast girders they were setting up in Windsor[45]. CSA followed up the process by a visit to the grounds of the new plant on May 30, 2012. A few days before the production of the girders began, CSA conducted an audit of the plant, that was held on August 2 and 3, 2012. During this audit, CSA representatives visited the Freyssinet plant and inspected every aspect of manufacturing precast prestressed concrete girders. The Report that was submitted by CSA following this visit revealed that there were a total of 13 items that needed to be addressed before CSA would grant the precast company its certification[46]. A follow-up visit from CSA on August 7 and 8, 2012 revealed that

[44] Section 2.8 of PSA
[45] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Chronology
[46] *Ibid.*, Tab 42

"8 of the 13 CSA non-conformances were rectified prior to August 7. Those that were not rectified were as follows:

- *Retention of Retained Engineer ("RE")*
- *Welder qualification to W186 standard*
- *Adding additional dial to read initial stress to 2% accuracy*
- *Obtaining calibration reports from ready mix suppliers*
- *Obtaining batch uniformity records regarding truck mixers."*[47]

One of these items was deemed especially critical by CSA, and this item consisted of hiring a "Retained Engineer". The Freyssinet plant began production on August 7, 2012[48] prior to receiving CSA certification of the plant yard in Windsor.

On October 29, 2012, HMQ requested evidence that the Freyssinet plant was compliant with OPSS 909, or SP OPSS 909S01, that requires that manufacturers need to have CSA, or Canadian Precast/Prestressed Concrete Institute (**"CPCI"**) certification for production of any precast pre-stressed

[47] *Ibid.*, Chronology
[48] *Ibid.*

concrete products[49]. Works committee meeting No. 22 was held on November 4, 2012 in which ProjectCo confirmed that only one non-compliance remained on the list of 13 issued by CSA. ProjectCo advised that the girders manufactured since August 7, 2012 would be able to be certified, as they had been produced using the same process as girders after CSA certification. HMQ wanted assurance that no girders would be placed *in situ* before their Certification[50].

On November 12, 2012, Freyssinet hired Ken Kapusniak, P.Eng. as its Retained Engineer. Among other crucial matters, the responsibility of this engineer was to sign a "Statement of Compliance" which was to certify that the material, production and quality control were maintained and products meet requirements of CSA A23.4-09. Some of the roles of the Retained Engineer are to

"• *Require correction of product deviations from Standards and CSA International requirements;*

• *Require changes in design drawings, procurement, etc. in accordance with CSA International requirements;*

[49] Letter from Fay Marzuq, HMQ to Ignacio Lasa of Project Co, Binder B3, Tab H-1
[50] August 20-21, 2013 presentation by ProjectCo to the IER Committee, Minutes of Works Committee Meeting No. 22, November 4, 2012, Binder B2, Tab G-1

- *Review and approve product releases and engineering changes to ensure compliance with CSA International requirements and communicate this to CSA International technical staff for final approval as applicable;*

- *Audit pre-cast concrete products under production to ensure continuing compliance with Standards and CSA International requirements*

- *Ensure that the Quality Assurance Program is implemented and being followed at the facility;"*[51].

It should be noted that Freyssinet did not have a Retained Engineer on staff until November 12, 2012. Shortly after, on November 19, 2012, they obtained their CSA certification. No girders were delivered to the site before November 19, 2012, although a total of 203 girders had been manufactured by November 19, 2012.[52]

A confirmation letter dated November 20, 2012 was issued by Demtew Tesfaye of CSA to Javier Gonzalo of Freyssinet that contained the following text related to girders built before this date:

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[51] Excerpt from the Quality System Manual of Freyssinet sent in an e-mail from ProjectCo's counsel to the IER Committee dated September 13, 2013
[52] August 20-21, 2013 presentation by ProjectCo to the IER Committee, Binder B2, Tab E2

> "*products that have been completed between (our) audit date of August 7, 2012 to current, upon review and acceptance and signing of statement of compliance by the retained engineer and the Quality Manager indicating that products have been manufactured in meeting with the project specifications and CSA Std. A23.4 requirements would be acceptable and could bear the certification mark.*"[53]

On November 20, 2012, ProjectCo forwarded evidence of Freyssinet's CSA certification and PSI's CPCI certification to HMQ.[54]

In a letter of November 27, 2012, I.O. was questioning the CSA certification of the girders manufactured in the Freyssinet plant between August 7, and November 19, 2012. The letter states that

> "*HMQ does not consider NU girders manufactured prior to the plant certification date of November 19, 2012 to be compliant with the PA requirements and accordingly not acceptable for use on the project*." [55].

HMQ expressed concern about the transparency of the certification process, and the long term durability, endurance and performance of the girders[56].

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[53] Letter from Demtew Tesfaye, CSA to Javier Gonzalo, Freyssinet, November 20, 2012, Binder B3, Tab H-2

[54] Letter from Ignacio Lasa to Fay Marzuq, Novemerb20, 2012, Binder B3, Tab H-3

[55] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 14

On December 20, 2012 a meeting was held between HMQ, Freyssinet, PIC and CSA to discuss the certification issue[57]. HMQ would not consider using the girders fabricated prior to November 19, 2012 until a proposal of how to continue was provided by ProjectCo[58].

On January 3, 2013, CSA performed another audit of the Freyssinet Windsor plant[59]. The CSA Pre-Cast Concrete Products Compliance Report stated that there was no need for follow-up. The review of the plant's Compliance Control Manual was satisfactory. There was no production the day of the audit, and it was said that the plant was setting up for cold weather concreting. The audit stated that the company was in the process of obtaining CSA W186 certification. Welders were certified under CSA W47.1 the day of the audit.

On January 16, 2013, a letter was issued from Ken Pengelly of CSA to Hannah Schell of MTO with further explanations of the CSA certification process[60]. The letter reiterates that, after receiving CSA certification, a professional engineer, registered in the province where the plant operates, takes full

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[56] August 20-21, 2013 presentation by ProjectCo to the IER Committee, Minutes of Works Committee Meeting No. 23, Binder B2, Tab G-2
[57] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 25
[58] IO letter of January 10, 2013 from Fay Marzuq to Ignacio Lasa, Exhibit X2, Tab H8
[59] August 20-21, 2013 presentation by ProjectCo to the IER Committee, CSA Pre-Cast Concrete Product Compliance Report, January 3, 2013, Binder B2, Tab E-5
[60] Exhibit X2, Tab H9

responsibility for the compliance of the plant. The entire production must comply with all applicable Codes and Standards. Ken Pengelly further stated that:

> *"(f)or the products manufactured during the evaluation phase, as long as full compliance to codes and standards is determined and all required alterations have been disclosed, stated to be put into effect and found to be satisfactory by CSA's certification engineer, the products in question may be marked with the appropriate CSA Group certification mark (CSA Mark) after the Certificate of Qualification Issuance date."*

Under the PSA, CSA certified products must be manufactured in compliance with the certification reports and all applicable standards. In cases where this compliance was not assured, CSA deems these cases to be misusing the CSA Mark and such manufacturers may lose their CSA certification.

On January 18, 2013, Ken Kapusniak, P.Eng. wrote a letter to Franck Chavent of Freyssinet, in which he stated that he has been familiar with the production of the girders in the Freyssinet plant, where he had served as Quality Verification Engineer ("**QVE**") from August 2012 to November 12, 2012, and later as the Retained Engineer. As such, he had no problem signing the CSA

Statement of Compliance forms for all girders manufactured in the plant to the date of his letter[61].

ProjectCo started to install girders at Tunnel T2 on January 21, 2013, without prior approval of HMQ[62]. By that date, HMQ had not received ProjectCo's proposal on how to move forward yet. Therefore, on February 6, 2013, Fay Marzuq of I.O. sent a letter to Ignacio Lasa, C.E.O. of WEMG, outlining several deliverables that were to be satisfied in order to move forward[63]. The following are the deliverables relevant to the CSA certification process:

- *"…HMQ requires clear documentation from CSA, regarding the status and acceptability of the plant, and the products manufactured at the plant between August 7 and November 19, 2012"*

- *"HMQ requires actual letter(s) of compliance (or those documents that, once signed, form letter(s) of compliance) be provided."*

- *"HMQ requires a letter that states that the Retained Engineer is the same engineer that performed the QVE work prior to November 19, 2012, clearly defines the differing roles of the QVE and of the Retained Engineer, and provides a detailed description of the actual activities and responsibilities of*

[61] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 30
[62] Exhibit X-2, Tab H12
[63] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 34

each regarding production of the girders manufactured from August 7 to November 19, 2012."

- *"Provide a comprehensive certification timeline, listing the findings of the original audit and providing the dates where the individual findings were satisfied, or the date when the finding will be satisfied in the event that there are findings from the audits of August 2012, that are still active*."

Further communication between the parties continued during the spring of 2013, however no formal agreement was reached on the issue of CSA certification of girders manufactured between August 7 and November 19 2012. As a result, on May 14, 2013, a "*Notice of Dispute Regarding Freyssinet Girders*" was sent by HMQ to ProjectCo[64]. The dispute was centered on a total of four (4) points, including the uncertainty of CSA certification of girders manufactured between August 7, 2012 and November 19, 2012 and eventually led to institution of the Independent Expert Review Committee.

Applicable Codes and/or Standards

All applicable Codes and Standards that need to be used in a project are specified in the Project Agreement. Schedule 15.1 "*Definitions and reference*

[64] Binder submitted at August 9, 2013 presentation by MTO to IER Committee, Tab 4, Letter by Fay Marzuq to Ignacio Lasa.

documents" lists approximately 200 reference documents that need to be adhered to in this project. The Ontario Provincial Standards Specifications (**"OPSS**") and Contract Design, Estimating and Documentation Manual (**"CDED"**) are listed as reference documents. OPSS 909 is the "*Construction Specification for Prestressed-Concrete Precast Members*", and SSP909S01 is a specification that applies to the Works under the Project Agreement. Clause 909.07.02 of this specification requires that "*Members shall be fabricated by a plant certified by Canadian Standards Association (CSA)…*". The procedure for the CSA certification process of precast concrete plants is covered in CSA Group DQD 218WI001, "*Guidelines on the Procedures for Certification of Pre-Cast Concrete Products*".

Compliance

The CSA certification process commenced on August 7, 2012 with a list of 13 non-compliances that needed to be addressed before certification would be awarded to the Windsor Freyssinet precast plant. A total of five (5) of these non-compliances remained unaddressed after August 8, 2012. The list of dates that these were satisfied was provided to CSA for certification purposes, and

by November 12, 2012 all of the non-compliances were satisfied[65]. CSA granted the plant their certification as of November 19, 2012. All the girders that were manufactured after the Freyssinet plant was certified were entitled to bear the CSA Mark and have no certification issues. The products manufactured between the date of audit, August 7, 2012, and November 19, 2012, the date of obtaining CSA certification, can be certified, if a statement of compliance were to be signed by the Retained Engineer and the Quality Manager confirming that the product had been manufactured in accordance with the requirements of the project specifications and CAN/CSA A23.4-09. A letter to that effect was provided by Ken Kapusniak, P.Eng. on February 18, 2013[66]. He confirmed that he was the QVE at Freyssinet before becoming the plant's Retained Engineer, that he was familiar with the production of the girders from August 2012 until the date of the letter, and that he had no concerns signing the CSA Statement of Compliance forms. It has to be pointed out that he was the only professional engineer registered in Ontario working at the plant[67] at that time and that he visited the plant whenever

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[65] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 42, Appendix 2.

[66] Exhibit X-2 of the August 20-21, 2013 presentation by ProjectCo to the IER Committee, Tab H11

[67] Transcript of the August 28, 2013 presentation by Freyssinet to the IER Committee, page 50, lines 19-24 (per Franck Chavent)

called upon, which was usually once or twice a week only[68]. The fact that the plant responsible for manufacturing hundreds of state-of-the art precast prestressed concrete girders did not have a full-time professional engineer registered in Ontario is troubling. The Project Agreement, at Schedule 15[69], states that the term “engineer” refers to an engineer registered in Ontario. None of the full-time engineers working in the Freyssinet facility in this period of time was a registered Professional Engineer of Ontario[70]. There is also no physical evidence that the girders were manufactured in accordance with the shop drawings following the applicable specifications.

The results of forensic decomposition of the girders from August 19 - 21, 2013 revealed several facts about the girders[71]. These included horizontal and inclined cracks in the web of girder ends and strand misalignment; and spacing between strands was not adhered to the design. Cracking was observed in nine girders and some of the cracks were described as ”thru cracks cutting through the width of the web”.

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[68] Transcript of the August 28, 2013 presentation by Freyssinet to the IER Committee, page 61 lines 5-7 (per Franck Chavent)

[69] Project Agreement, Schedule 15-1, page 7, definition of Engineer

[70] Correspondence from Franck Chavent of Freyssinet to Daniel Ruiz of PIC, September 13, 2013

[71] Letter from CH2MHILL to Tom Woods, IO dated August 28, 2013

These findings relating to strand spacing show non-compliance with Clause 14.2 of CSA A23.4-09, which provides that

> *"the location of individual pretensioning tendons shall be shown on the shop drawings. At the ends, the minimum clear spacing shall be 2-1/4 times the nominal bar diameter of the individual tendon, but not less than 1-1/2 times the nominal maximum size of coarse aggregate."*[72]

The clear spacing of the tendons in Girder T7-B60 and Girder T7-B12 were observed to be less than 50 mm[73] which violates the specifications. There was also non-compliance with Clause 14.3 of CSA A23.4-09, which states that:

> *"(t)he size, shape, and spacing of all reinforcement shall be checked against shop drawings. The reinforcement shall be placed in the forms within the tolerances specified in Clause 14.4. Any variations in spacing of reinforcement exceeding tolerances shall be corrected."*[74]

Table 3 of OPSS 905 states that, if rebars are

> *"3. …(i)n two or more layers, the rebar shall be directly above one another and the clear distance between layers shall not be less than 25 mm.*

[72] CSA A23.4-09, Clause 14.2, page 19
[73] Letter from CH2MHill to Tom Woods dated August 28, 2013
[74] CSA A23.3-09, Clause 14.2, page 19

4. *The size, number, and spacing of bars shall be as specified in the Working Drawings."*[75]

The tendons in Girder T7-B12 were shown in a photograph to be misaligned, and crossing each other[76], clearly violating the above requirements.

Implications Insofar As Safety and Durability of Girders are Concerned

The CSA certification requires that products are manufactured according to applicable standards to maintain product safety. The certification process was followed by Freyssinet to CSA's satisfaction. It remains to be considered, however, why the system, as it was applied in this case, did not result in production of girders that did not follow the details outlined in the drawings and did not meet the requirements of the applicable codes. The pivotal issue in the production of safe and durable girders is quality control, compliance with codes and standards, and competent workmanship. It is through the role of the Retained Engineer that CSA enforces this quality assurance. Since there was no Retained Engineer on site before November 19, 2012, no one had the authority to stop the production if required due to quality issues and when the rules were not followed and the construction was faulty. The fact

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[75] OPSS 905, "Construction Specification for Steel Reinforcement for Concrete", April 2007, page 14
[76] Letter from CH2MHill to Tom Woods dated August 28, 2013

that CSA did not require the full-time employment and presence of a Retained Engineer on site affected the quality of the manufacturing process. As a result, the test results from Girder T7-B12, manufactured on September 25, 2012[77], and Girder T7-B60, manufactured on October 29, 2012[78], show many signs of a lack of on-site inspection that directly affects the safety and durability of these girders. These signs include the presence of horizontal and diagonal cracking in the end zone of girder web most likely due to overstressing, or lack of reinforcement in the transfer zone. Such cracking, if not repaired appropriately, would provide easy access for water and/or de-icing chemicals into the girder, and speed up the corrosion process of reinforcing steel. The lack of quality control in proper placement of reinforcement is especially troubling. How and where the reinforcement is placed is one of the most important components of reinforced and prestressed concrete construction. Reinforcement needs to have sufficient concrete cover in order to develop its full strength, and therefore misaligned prestressing tendon may negatively affect the serviceability of the girders. Products manufactured with a lack of quality control cannot be deemed safe or durable, because even small deviations from shop drawings have the potential to lead

[77] Transcript of review session on August 21, 2013, at 9:30 a.m., page 121, lines 5-6
[78] *Ibid.*, page 121, lines 9-10

to major problems immediately or in the future. Since the position of the Retained Engineer was not filled for the first few months of the production process, issues that could have been dealt with in accordance with CSA Certification requirements were not, and hence resulted in an unsafe and potentially non-durable product.

CERTIFICATION OF WELDERS

Facts

When the Freyssinet precast plant underwent its audit to secure CSA Certification, one of the 13 non-conformances identified by the visiting CSA team was that the welders working on site were not certified to CSA W186 "*Welding Reinforcing Bars in Reinforced Concrete Construction*". The welders were certified to CSA W47.1 "*Certification of Companies for Fusion Welding of Steel*"[79]. The Freyssinet plant began girder production on August 7, 2012. At this point the welders performing the work

[79] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 42, CSA Audit Certification Checklist, August 2, 3, 7, and 8 2012

"… were not certified to CSA W186."[80]

In a letter to ProjectCo dated February 6, 2013, I.O. introduced an eight (8) point deliverables program that among other items requested to

> *"(p)rovide a comprehensive certification timeline, listing the findings of the original audit and providing the dates where the individual findings were satisfied, or the date when the finding will be satisfied in the event that there are findings from the audits of August 2012, that are still active. "*[81]

One of the items listed that still required attention was the fact that the individual welders in the Freyssinet plant were not certified to CSA W186. I.O. sent a further letter to ProjectCo requesting the outstanding information. I.O. identified seven (7) outstanding points in this letter that was sent on March 20, 2013. Point number 4 inquired:

> *"…are the welders and welding inspector qualified and the company performing the tack welding certified, all to W186?"*[82]

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[80] Letter from Scott Griffin of GS Inspection Consultants to Mr. De Saboulin-Bolena of Freyssinet, dated August 9, 2013, Binder 1, Tab B25

[81] Letter from Fay Marzuq to Ignacio Lasa, February 6, 2013; IER Committee at the August 9, 2013 presentation by MTO, Tab 4, page 3 of the letter

[82] *Ibid.*

Freyssinet responded to this letter on April 18, 2013, stating that the plant's welding supervisor had implemented ISO certified procedure for welding in the plant, that their welders were fully CSA W47.1 certified welders, and that they were applying for CSA W186 certification[83]. On April 23 2013, NCR #211 entitled "*Use of Tack Welds in Precast Girders and Use of Non-Qualified Welders (CSA W186)*"[84] was activated. This NCR brought up the issue of non-CSA W186 qualified welders again. A letter from ProjectCo on May 10, 2013 further clarified that the tack welding in the Freyssinet plant was inspected by a CSA W186 certified supervisor[85], Scott Griffin of GS Inspections.

Applicable Codes and/or Standards

OPSS 909.07.04 provides that

> *"(w)elding of reinforcing steel bars shall be according to CSA W186 and performed by a qualified welder working for a company certified by the Canadian Welding Bureau according to CSA W186."*

Welders are to perform welding according to Clause 14.5 of CSA A23.4-09, which states: "*Welding of reinforcement (including tack welding) shall comply with*

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[83] Letter from Franck Chavent to Daniel Ruiz of PIC on April 18, 2013, Exhibit A1, Tab 61
[84] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 59
[85] ProjectCo proposal, Letter No.: WEP-PIC-LET-WEM-0594, Exhibit A1, Tab 66

CSA W186." CSA W186 "*Welding of Reinforcing Bars in Reinforced Concrete Construction*" must be adhered to when welding is required for all reinforcement in reinforced concrete structures. The required qualification for tack welding is specified in CSA W47.1 in Clause 9.14.4[86].

Clause 8.3.2.1 of CSA W47.1 states that

> *"(a) tack welder's qualification shall remain in effect indefinitely (while the tack welder is employed by a certified company)…"*[87].

Compliance

The CSA audit of the Windsor Freyssinet plant on August 2, 3, 7 and 8, 2012 revealed that there was a non-compliance issue regarding welders on site that were not certified to the required standard, W186[88]. At that time, welders were certified to CSA W47.1 and were following ISO certified welding procedure. The welds and the welding procedure were inspected by a CSA W186 certified supervisor[89] when the plant was setting up its operation in early August 2012. As stated in a letter from Franck Chavent on April 18,

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[86] CSA W47.1, Certification of Companies for Fusion Welding of Steel, Clause 9.14.4, page 25
[87] CSA W47.1, Certification of Companies for Fusion Welding of Steel
[88] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 30, Pre-cast concrete products certification program checklist, page 14 of 31
[89] Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, Tab 66

2013[90], the plant was in an application process to receive CWB W186 certification. A May 10, 2013 letter from Mr. Hatchell identified that only one (1) out of four (4) welders was certified to CSA W186[91] a full nine (9) months after the start of operation of the plant. This shows non-compliance with CSA Certification requirements. However, it appears that for the application of tack welds in particular, the company's welder certification to CSA W47.1 was sufficient, provided the company is certified to CSA W47.1. The documentation provided to the IER Committee only showed certification to CSA W47.1 until December 1, 2012[92].

Implications Insofar as Safety and Durability of Girders are Concerned

The codes are clear on the fact that welding of reinforcement needs to be performed by certified welders. Certifications vary based on the difficulty of the tasks performed, and CSA clearly states that welders that perform work on reinforcing cages need to be certified to CSA W186. Tack welders' certification, though, is covered under CSA W47.1. However, because they are using this welding technique on reinforcing cages, they need to get CSA W186 certification, as CSA W47.1 applies to welding of structural steel.

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[90] *Ibid.*, Tab 61

[91] *Ibid.*, Tab 66

[92] CWB Letter of Validation, Exhibit A-1 of the August 20-21, 2013 Presentation by ProjectCo to the IER Committee, tab 42

TACK WELDING

Background

The Parkway is a six-lane depressed highway which traverses eleven tunnels with lengths up to 240 metres. Each tunnel was formed by bridging the highway with closely spaced prestressed concrete girders, supporting a continuous concrete slab cast over the girders. This slab-on-girder structure constitutes the 'roofing' of the tunnel and also serves as a wide bridge to carry any combination of local roads, pedestrian and wildlife pathways, utilities and landscaped areas.

Concrete as a material is very strong in compression but weak in tension therefore embedded steel reinforcement is used to provide the tensile strength needed to make up a girder. This reinforcement consists of engineered shaped steel rods wire-tied together to form the reinforcing cage that is buried in the concrete. Engineering drawings detail each reinforcing bar in terms of size, shape and placement in the girder as designed by the engineer in accordance with good engineering practice and pertinent references in the Project Agreement. The properties of both concrete and steel are specified by the design engineer in compliance with the appropriate Codes, Ontario

Provincial Standards and Specifications, and applicable Special Provisions for materials and construction.

Fig. 1

During design development ProjectCo and its design consultant Hatch Mott Macdonald (**"HMM"**) proposed that the original girders be redesigned as Nebraska University (**"NU"**) girders. NU girders differ from traditional girders in that the process of assembling and fastening discrete bars one–by-one to form the reinforcing cage is replaced by a line of sub-cages coupled to one-another, to make up the entire girder reinforcement cage. Each sub-cage

is assembled by fastening together custom made welded wire-reinforcement ("**WWR**") mesh, bent and trimmed, to the desired shape[93]. (see Figs. 1, 2, 3)

Before start of girder fabrication, ProjectCo contracted e.Construct to redesign the girders as NU girders for the project. The developer of the NU Girder was e.Construct Consulting Engineers in Omaha, Nebraska, United States. The girder manufacturer Tierra Armada or Freyssinet had built a new precast yard[94] in Windsor, Ontario close to the construction site.

For reasons of compliance with the requirements of Professional Engineers Ontario, e.Construct entered into an agreement with HGS Consulting Engineers ("**HGS**"), registered in Ontario, to seal and stamp the design drawings. Later, Freyssinet contracted e.Construct to prepare the necessary shop drawings (or working-drawings, see SP 909S01 Cl. 909.04.02.02), also sealed and stamped by HGS, for manufacturing the NU girders.

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93 NU Girders slide presentation to MTO SW Region, September 22, 2011; MTO binder tab 2
94 Presentation slides 36-50 ProjectCo Presentation; exhibit X-1

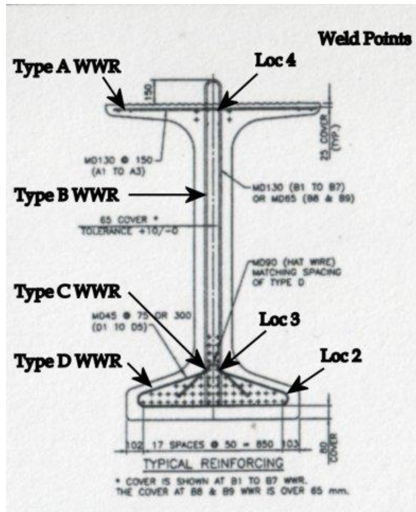

Fig. 2 Typical Cross-Section

In addition to wire-tying the WWR reinforcing steel cage, tack welding (see Fig. 4) was also used for the construction of cages for girders in contravention of the CHBDC published by the Canadian Standards Association as CAN/CSA-S6-06. The breach of the Project Agreement due to tack welding could have adverse implications for the project. This section of the report investigates why tack welding was done and, if there are implications to safety and durability of the girders, what might those be and what measures are recommended to meet the objectives of the Project Agreement.

Fig. 4 Tack welds typical

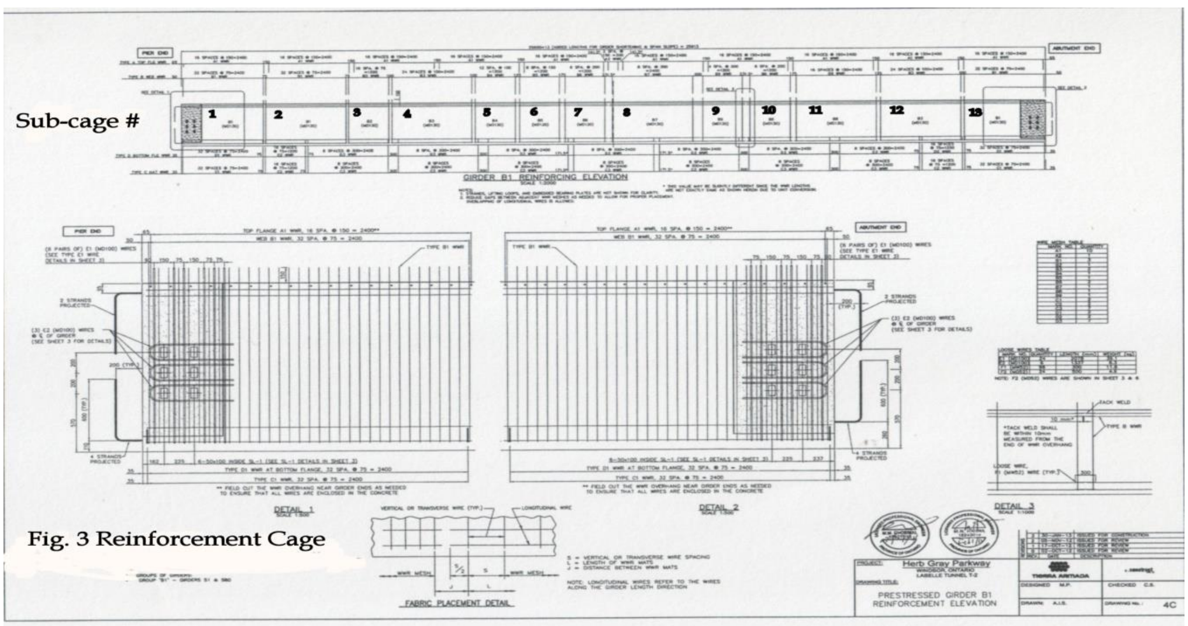

Fig. 3 Reinforcement Cage

Facts

This review concerns the 500 girders produced until May 31, 2013 when Freyssinet production ceased. Between August 7, 2012[95] and November 19, 2012[96], the Freyssinet precast yard was not certified by the CSA, as discussed elsewhere in this report. Girder fabrication[97] appears to have started on August 2, 2012 according to the dates on inspection records and interview notes.[98,99,100] The total number of girders produced by the non-certified plant was 203[101], of which 50[102] were permanently installed in tunnel 2 (**"T2"**) and 153 were installed in tunnel 7 (**"T7"**). The term "installed" was used in the project to mean girders placed on the structure in their final locations but with no deck-slab constructed. After casting the deck-slab the designation changes to "permanently-installed". The table in the Introduction shows the location of all 203 girders on August 20, 2013. The remaining 297 girders were stored at different places on site.

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95 Minutes of meeting #22 section 4.0 TA §1, date November 01, 2012; I.O. binder tab 09

96 Letter WEMG dated November 20, 2012, attach Certificate of Qualification; I.O. binder tab 13

97 This report differentiates 'girder fabrication' meaning manufacturing of the reinforcement cage, and 'girder production' meaning the completed concrete beam

98 GS Inspection – Daily Inspection Report A1 typical dated August02, 2012; ProjectCo 2/3 binder tab 26

99 Transcript of interview with Scott Griffin, August 28, 2013; page 5 line 20.

100 Transcript of interview with Freyssinet, August 28, 2013; page 9 line 4, page 10 line 2, page 12 line 19.

101 Minutes of meeting #23, Sec 4.0, TA §3, dated December 06, 2012; I.O. binder tab 18

102 Table titled "Girders in T2, T3, T5 and T7" rcvd August 21, 2013; ProjectCo exhibit X6

Similarly to other bridge codes, CAN/CSA S6-06 Clause C8.5.3 – Fatigue Limit State, reads "Tack welding of reinforcing bars is not permitted, since it can reduce fatigue resistance by creating a stress-raising notch effect." Quoting from the U.K. Design Manual for Roads and Bridges[103] Volume 1 Section 3, Part 4:

> *"1.2 Tack welding of reinforcing bars can be used under carefully controlled conditions. Good quality tack welds can improve the construction process and lead to improvements in the quality of location of reinforcing steel and of cover. However in some situations tack welds, even of good quality, can_drastically reduce the fatigue strength of reinforcement; while poor quality tack welds can lead to substantial loss of strength and embrittlement, as well as to shorter fatigue lives."*

In the same document:

> *"2 ENGINEER'S APPROVAL FOR THE USE OF*
>
> *TACK WELDING" under "2.3 The fatigue strength of tack welded reinforcing bars should be assessed in accordance with Chapter 4 and should be submitted to the Engineer for approval before commencing tack welding." and also under*

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[103] Department of Transport U.K. Highways Agency, Design Manual for Roads and Bridges: Volume 1 Highway Structures Approval Procedures and General Design: Section 3, Part 4 BA40/93 Tack Welding of Reinforcing Bars.

"2.4 Before commencing tack welding the welding procedures for shop and site tack welds should be submitted to the Engineer for approval in accordance with the requirements of BS 7123 Specification for Metal Arc Welding of Steel for Concrete reinforcement."

The equivalent of the CWB in the United States, The American Welding Society produces a standard equivalent to CSA W186, which is "AWS D1.4 Structural Welding Code –Reinforcing Steel". Clause 4.2.5 reads:

"Welding of bars which cross shall not be permitted unless authorized by the Engineer."

The NPCA (National Precast Concrete Association) Publication March-April 2011 – Hot Topic Welding Reinforcement, by Claude Goguen, P.E. LEED AP, citation of excerpts:

"Proper practice in the welding of reinforcement is of particular importance in the precast industry. Welding of reinforcement can serve both as a means of expediting the production process and of creating material savings. However, it is important to exercise caution to ensure safe practices and to produce quality structural welds that maintain both steel strength and concrete structural integrity… The first is American Concrete Institute's ACI 318-08, Building

Code Requirements for Structural Concrete and Commentary. Section 3.5.2 of ACI 318-08 states that welding of reinforcing bars shall conform to AWS D1.4 and that type and location of welded splices and other required welding shall be indicated on the design drawings or in the project specs."

And further on:

"Recommended tack welding practices and C.E. (Carbon equivalence) values that are indicated in the specifications/codes listed in this article must be followed in the field to ensure that reinforcing cages are properly fabricated. The reason this is so important is because poor-quality tack welds on reinforcing cages not only can decrease steel yield strength, but can also decrease the concrete's fatigue life and durability. So remember the next time you consider welding steel rebar without first confirming what type of steel it is and ensuring that it is truly weldable, the sparks that fly after a structural failure may make your torch look dim in comparison."

Variances from CAN/CSA S06-06 clauses are possible, if duly justified, under C1.4.1 – Approval, which reads:

"...C1.4.1 establishes general interpretation guidelines and permits departures and variations from the Code subject to Approval."

Reinforcing bars Type B WWR in the web of the girders are stirrups (see Fig. 2), which are subjected to high stress under service loading and to fatigue, and therefore are critical to the safety of the girders.

All 500 girders have been tack welded. Unauthorized use of tack welding constitutes non-compliance with Project Agreement Schedule 15-2, Part 2, Article 3, Clause 3.1 (a)(11).

The facts gleaned by the IER Committee are presented more or less chronologically below.

Fact 1[104] – July 31, 2012: Shop drawings for T7 Rev.1 (latest) issued for construction; drawings sealed and stamped by L. Qian and M.M. Ghobrial.

Tack welding was shown on shop drawings as Detail 3 referring only to the connection between adjacent reinforcement cages (*Note: the loose wires lap the overhang wires from adjacent sub-cages*).

Fact 2[105] - August 2, 3, 7, 8, 2012: CSA engineer visited the Freyssinet Plant to conduct the audit for certification to CSA A23.4. Freyssinet had also contracted GS Inspection Consultants to inspect welding practices.

[104] Drawings 3B, 3C Tunnel 7; ProjectCo binder 2/3 tab 21
[105] Letter WEMG dated January23, 2013, attach PIC letter; I.O. binder tab 30

The first three cages for girders A1, A2, A3 were ready for inspection by the CSA engineer on August 02, 2012. Freyssinet had also arranged for GS Inspection Consultants to do some welding inspection described as:

> *"…that there was some tack welding on these cages and they wanted to have a third party inspect them."*[106]

(*Note: One reinforcement cage is made-up of many 'in-line' sub-cages, attached together by 'the loose wires' (see Fig. 3*)).

On site Freyssinet told Scott Griffin of GS Inspection Consultants that the scope of the assignment was to be:

> *"Just to make sure that the loose wires that go in between the sections of the cages were installed properly, tack welded properly. That was the main scope of work."*[107]

Tack welding was therefore used from the beginning of fabrication of reinforcement cages at the Freyssinet plant.

Although Scott Griffin had plenty of experience inspecting tack welding of structural steel,[108] the same was not the case with reinforcing steel bars for

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[106] Transcript of interview with Scott Griffin, August 28, 2013; page 5 line 7
[107] *Ibid.*, page 06 line 4

reinforced concrete, since he had never been asked to inspect tack welding by a precast concrete manufacturer.[109]

On site Freyssinet provided Scott Griffin with shop drawings of steel reinforcement,[110] sealed by two professional engineers, for him to work from.[111,112]

No other briefing on the project was given to Scott Griffin neither was he provided with the pertinent CHBDC and other Standards, in the manner other clients normally do.[113]

Scott Griffin saw undercutting[114] and the need for some welding repairs.[115,116,117] He called on the welders to do these repairs.[118]

Scott Griffin noticed additional tack welding that was not in his scope of work.[119] This tack welding was on each sub-cage but he could not remember how frequent they were and what was their spacing.[120]

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108 *Ibid.*, page 8 line 11
109 *Ibid.*, page 17 line 1, page 62 line 20
110 IERC received scanned copies from Scott Griffin which confirmed they were same as in footnote 7
111 Transcript of interview with Scott Griffin, August 28, 2013; page 10 line 18-line 23
112 Transcript of interview with Freyssinet, August 28, 2013; page 13 line 18
113 Transcript of interview with Scott Griffin, August 28, 2013; page 16 line 22-page 18 line 10
114 *Ibid.*, page 56 line 3, page 56 line 11
115 *Ibid.*, page 57 line 4, page 24 line 10
116 Transcript of interview with Freyssinet, August 28, 2013; page 13 line 04
117 GS Inspection Consultants – Daily Inspection Report A1 typical, dated August02, 2012; ProjectCo binder 2/3 tab 26
118 Transcript of interview with Scott Griffin, August 28, 2013; page 57 line 06, page 24 line 10

Scott Griffin observed the additional tack welds which in his view were good tack welds, adequate, acceptable[121]. (*Note: However, he was not aware that he was inspecting to CSA W59 Welded Steel Construction instead of CSA W186 – Welding of Reinforcing Bars in Reinforced Concrete Construction.*)

On being asked why he, not especially skilled on tack welding of reinforcing steel, was called-in by Freyssinet, Scott Griffin answered:

> *"...I think they were looking for -- as part of the certification process they were trying to achieve, they felt it would be good to have a third party to come in and look at the start-up of their process."*[122,123]

Later Scott Griffin also said:

> *"I believe they wanted a third party to make sure the tack welding and how the welders were doing their job was inspected by a third party to facilitate the certification process."*[124]

However, Freyssinet's explanation for the presence of a welding inspector during the CSA audit of the plant was as follows:

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119 *Ibid.*, page 16 line 5
120 *Ibid.*, page 14 line 3
121 *Ibid.*, page 54 line 18, page 48 line 17
122 *Ibid.*, page 08 line 04
123 Transcript of interview with Freyssinet, August 28, 2013; page 10 line 12
124 Transcript of interview with Scott Griffin, August 28, 2013; page 60 line 6

> *"...were there in presence of the CSA engineer for inspection of those cages...First they qualify the cage reinforcement steel,...We coordinated so that both our welding inspector and the CSA auditor engineer were there to be able to speak to each other and see what kind of control we would have on our cage. That was purposely that we had those people meeting on site to have the first step of the inspection, which consists of the reinforcing cage."*[125]

It is unclear when Franck Chavent says "...so that both our welding inspector and the CSA auditor engineer..." if "both our welding inspector" refers to Scott Griffin as "our welding inspector" or if there was a third person from Freyssinet present. Further along the interview Freyssinet said "...The engineer from CSA and level 2 inspector Scott were on site along with our personnel. Scott remembers speaking to one of our qualified welders that time to have interaction of the work performed, the control, the 14 visual…"[126]

To Scott Griffin's surprise[127], GS Inspection Consultants assignment ended on the same day the CSA audit ended (Aug 08, 2012).

Scott Griffin said that welders self- inspect their own work.[128,129]

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[125] Interview Freyssinet page 10 line 14, date August 28, 2013; transcript
[126] *Ibid.*
[127] Transcript of interview with Scott Griffin, August 28, 2013; page 48 line 3, page 59 line 10
[128] *Ibid.*, page 57 line 4

It became evident that from August 8, 2012 there was no more independent welding inspector on site.

Non-comformance items from CSA audit:

CSA audit checklist [130]

> *"Item 4 - Welding of rebar cages must keep the geometric shapes and spacing of bars as shown on shop drawings; connecting bars (loose wires) between rebar cages (sub-cages) not welded as per drawing No.3B and 3C,[131]and WWR cages (sub-cages) not cut to required end shape and dimensions. General welding quality was not satisfactory showing undercuts to the bars and also not providing the geometric shape to meet concrete cover requirements."*[132]
>
> *(Note: Poor workmanship of WWR for the sub-cages explains need for more tack welding to hold down ill-fitting parts in place)*

Scott Griffin said that he might have questioned tack welding of Type D WWR in the bottom flange to the Type B WWR verticals (stirrups) and he was

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129 Transcript of interview with Freyssinet, August 28, 2013; page 12 line 15, page 105 line 5
130 Letter WEMG dated January 23, 2013, attach PIC letter; IO binder tab 30
131 Drawings issued for construction; ProjectCo binder 2/3 tab 21
132 Transcript of interview with Scott Griffin, August 28, 2013; page 15 line 9

told that it was to hold the Type D WWR in the place for the required concrete cover.[133]

Fact 3 – August 2012: Freyssinet appointed Ken Kapusniak, P.Eng. as QVE[134] (*Note: In the reference document OPS909 for the role of QVE is cited, but the correct one is SP199S48*). However, Ken Kapusniak is not an employee of Freyssinet.

Ken Kapusniak had worked for concrete precasting companies.

Ken Kapusniak is not a structural engineer[135] and has limited bridge girder experience in Ontario.[136]

Ken Kapusniak's role as QVE[137,138] on quality control[139,140] has no inspection role and yet Franck Chavent (Freyssinet) relied on him for welding quality.[141]

Ken Kapusniak's views on approvals[142] and 'means and method':[143]

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133 *Ibid.*, page 16 line 12, page 24 line 01
134 Letter WEMG dated January 28, 2013, attach PIC Appendix 5 letter; IO binder tab 42
135 Transcript of interview with Ken Kapusniak, August 28, 2013; page 40 line 01
136 *Ibid.*, page 6 line 7, page 7 line 02, page 10 line 8
137 Quality Verification Engineer Services SP199S08, December 2005; attachment 1
138 Transcript of interview with Ken Kapusniak, August 28, 2013; page 9 line 1, page 65 line 10, page 66 line 2, page 73 line 13
139 Transcript of interview with Freyssinet, August 28, 2013; page 15 line 6
140 Transcript of interview with Ken Kapusniak, August 28, 2013; page 8 line 20, page 67 line 5, page 67 line 21, page 70 line 21
141 Transcript of interview with Freyssinet, August 28, 2013; page 109 line 19, page 15 line 3
142 Transcript of interview with Ken Kapusniak, August 28, 2013; page 22 line 11, page 22 line 18, page 22 line 24, page 23 line 12, page 24 line 2, page 24 line 21, page 25 line 8, page 27 line 5, page 28 line 20, page 28 line 24, page 32 line 10, page 32 line 20
143 *Ibid.*, page 33 line 16, page 35 line 10, page 37 line 08

(*Note: Ken Kapusniak claims that in his experience with Ontario and MTO all stirrups are welded and says that the whole industry will justify it as 'Means and Method'*.[144])

'Means and Method' is a production technique using tack welding to stiffen the reinforcement cage. At Freyssinet the decision is made by the welding superintendent (production) without consultation of the QVE or sanction by the design engineer.[145,146]

Freyssinet stated that e.Construct was informed of tack weld at location 3 (see Fig. 2) and asked to modify a final version of the shop drawing to show tack welding. The revision by e.Construct consisted in adding tack welding at location 1 (see Fig. 6). It was also stated that it is not typical to show tack welds on shop drawings.[147]

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144 *Ibid.,* page 32 line 20, page 33 line 1, page 34 line 3
145 Transcript of interview with Freyssinet, August 28, 2013; page 16 line 14, page 17 line 14
146 *Ibid.,* page 14 line 14, page 16 line 6, page 29 line 25
147 Transcript of interview with Franck Chavent, August 28, 2013; page 20 line 15, page 22 line 19

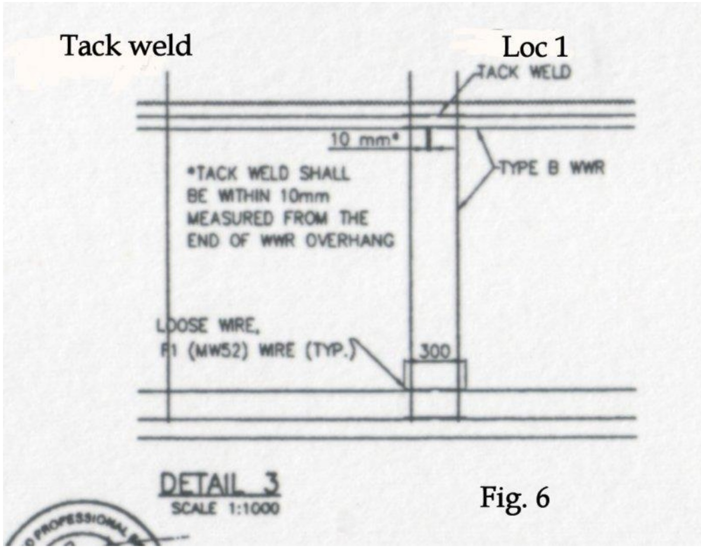

Fig. 6

Ken Kaspuniak sealed and signed Statements of Compliance, Certificates of Conformance,[148] Interim Inspection of Fabrication Certificate, and Permission to Proceed documents.[149]

Ken Kapusniak was on site on average one day a week.[150,151]

Fact 4[152] - August 2, 3, 7, 8, 2012: Freyssinet Plant CSA certification audit checklist of items pertinent to tack welding.

"Item 1- Evidence that a retained engineer understands the responsibility of signing 'Statement of Compliance" showing that material production and quality control is maintained and products meet A23.4."

148 Letter WEMG date February28, 2013, Appendix 3, 4; IO binder tab 42
149 Letter WEMG dated March 28, 2013, Identification Label; IO binder tab 53
150 Transcript of interview with Ken Kapusniak, August 28, 2013; page 65 line 02
151 Transcript of interview with Freyssinet, August 28, 2013; page 15 line 13
152 Letter WEMG date January 23, 2013, attach; IO binder tab 30

"Item 3 - Welding of rebar must conform to Clause 14.5 of A23.4 (to CSA W186); on site welders certified to W47.1 with welding checked by a welding supervisor accepted to client(only temporary till welders certified to W186)."

"Item 9 - Repair method shall be documented in the QSM [Quality Control/Assurance Manual] in accordance with Section 33 of A23.4."

Fact5[153,154] - October 26, 2012: "MTO and IO aware that production of girders started at Freyssinet without CSA certification." Also CMT #90 on Dec 17, 2012 item# CMT-0301.

Fact 6[155] – November 2012: Freyssinet appointed Ken Kapusniak, P.Eng. as RE and QVE.[156,157] Although Freyssinet did not see a conflict of interest in this appointment Ken Kapusniak's letter dated January 18, 2013 states "I was involved with the redesign of the girders through e.Construct."

Ken Kapusniak said he communicated frequently by phone and e-mail with the sitewhich he visited about once weekly.[158]

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153 Slide 3, IER of Certain Girders for Rt. H. H. Gray Chronology; August 13, 2013
154 Minutes of meeting CMT#90 dated December 17, 2012; IO binder tab 21
155 Letter WEMG dated February 28, 2013, Appendix 6; IO binder tab 42
156 Transcript of interview with Ken Kapusniak, August 28, 2013; page 71 line 3
157 Transcript of interview with Freyssinet, August 28, 2013; page 32 line 3
158 Transcript of interview with Ken Kapusniak, August 28, 2013; page 74 line 13

Fact 7[159] **-** November 20, 2012: Freyssinet Canada issued CSA Certification of Qualification to A23.4 date of issue November 19, 2012

Fact 8[160] - November 27, 2012: I.O. stated Nov 01, 2012, that girders manufactured prior to CSA certification are not compliant with the Project Agreement.

Fact 9[161] – December 04, 2012: Letter from PIC dated December 03, 2012 – 'We have requested clarification of CSA's position on certification of production completed during implementation Phase II and Phase III of the certification program. CSA has replied with a letter dated November 20, 2012 (copy attached)." CSA has retroactively attributed the same certification to the girders manufactured between Aug 07, 2012 and Nov 19, 2012. The Retained Engineer and Quality Manager must jointly sign a statement of compliance.

Fact 10[162] - December 6, 2012: Minutes under Tierra Armada Certification Status

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[159] Letter WEMG dated November 20, 2012, attach PIC letter; IO binder tab 13
[160] Letter I.O. dated November 27, 2012; IO binder tab 14
[161] Letter WEMG dated December 04, 2012, attach PIC letter; IO binder tab 17
[162] Minutes of meeting #23 date December 06, 2012; IO binder tab 18

PIC are carrying out individual quality inspections of all girders (so far 20 girders proposed for use in T2 have been inspected with 1 rejection – this beam has been recast)

- A total of 203 girders were commenced in production prior to 19th November (of these 3 have been rejected and re-cast under TA's own QA process)

Fact 11[163] - January 30, 2013: Tunnel-2 working drawings Rev.3 (latest) issued for construction; drawings sealed and signed by M.M. Ghobrial and M.N. Hanna. Tack welding was shown on shop drawings as Detail 3 referring only to the connection between adjacent reinforcement cages (*Note: the loose wires lap the overhang wires from adjacent sub-cages*). (Fig. 6)

Fact 12[164] - February 6, 2013: I.O. states that girders are not in accordance with the Project Agreement the reasons being:

- Per Project Agreement Schedule 15-2, Part 2, Article 3, Clause 3.1 (a)(11) the girders do not meet the requirements of the CHBDC Clause 8.5.3.1.

[163] Letter WEMG dated April 26, 2013, PIE letter, Appendix 3; IO binder tab 61
[164] Letter I.O. dated 2013-02-06; I.O. binder tab 34

- The welding does not meet the requirements of OPSS 905 Clause 905.07.02.06 which states that "steel reinforcement shall not be welded, including tack-welds, except as shown in the Contract Documents or as shown on the welding details submitted to the Contract Administrator". In this case we note that the HMQ-Reviewed Issued for Construction drawings do not include any reference to tack welding, and that HMQ has not been provided with any welding details as would have been required under Project Agreement Schedule 15-2, Part 1, Article 1, Clause 1.1(a)(iv).

In addition to this, we note that HMQ staff has been at the fabrication facility and noted tack welding occurring in locations not shown on fabrication drawings, and that the CSA compliance documents provided indicated that welding was "not satisfactory" and showed "undercuts to bars". Accordingly, "HMQ believes that these parts of the Works fail to comply with Project Requirements."

Fact 13[165] - February 27, 2013: Letter from PIC in response to Fact 12 –

[165] Letter WEMG dated February28, 2013, attach; I.O. binder tab 42

Deliverable 4 & 6 - Appendix 7 letter from e.Construct dated February 18, 2013 to Freyssinet –

§1 "Per your request, this letter is to explain the need (?) and nature of the welding as required in the WWR in the precast yard."

§2 "Based on the input from your production people in the field, tack welds are used at a total of four locations:" (Fig. 2, 6)

"Location 1: Between longitudinal wires of adjacent Type B WWR (Fig. 6) using additional loose wires – "… Additional wires are used to join the adjacent sheets through welding." "The tack welding is in areas where welding does not have a negative impact on structural performance."

"Location 2: Between transverse wire of Type C WWR and transverse wire of Type D WWR in the girder bottom flange - "Type D WWR is provided to confine the prestressing strands in the bottom flange. It is subject to a maximum force at the time of prestress release. Once the strands are released, Type D WWR is subject to a lower force due to prestress losses. It is our understanding that the girders have not exhibited cracking.

Cracking has been detected in numerous girders on site. Cracking appears to be due to bursting stresses[166].

The eConstruct report continues:

> *"at the time of prestress release. It indicates that Type D WWR has adequate strength to carry the prestressing force despite of the tack welds existed at a certain spacing (6 wire spacing in Fig. 3). Therefore, the tack weld is acceptable."*

The reference to 6 wire spacing of tack welds came from Freyssinet site staff as cited at the beginning of the eConstruct letter above:

> *"Location 3: Between transverse wire of Type B WWR and longitudinal wire of Type D WWR in the girder bottom flange – "The most critical portion of Type B vertical wires is near/mid-height of the girder section, which is subject to highest shear stresses. As illustrated in Fig. 2, the weld is located in the bottom flange, which is a low stress region and does not result in concerns on fatigue."*

(*Note: Web shear failure results from inclined cracking of the web due to yielding of the stirrups not only at mid–height; area near bottom flange is not a low stress region.*)

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166 Letter from CH2MHILL dated August 28, 2013. Although photographs refer to girders for T5 the construction process has not changed since August 07, 2012.

"Also, it does not affect the development length of the vertical wires"

(*Note: Refer to HMM June 7, 2013 Technical Memo pg4 showing a shear stress of ~2 MPa at weld level reason for concern with development length*),

"therefore, it does not impose an adverse effect on the girder shear capacity."

"Location 4: Between transverse wire of Type A WWR and longitudinal wire of Type B WWR – Our calculations show that the deck slab does not crack due to the additional dead and live loads (see Appendix). It is found that MD130 is below the neutral axis (N.A.) once the composite section is formed, i.e. MD130 starts to be subject to compressive stress due to superimposed dead and live loads. Therefore the fatigue stress is not a concern."

"In conclusion …It is our professional opinion that all areas meet or exceed the CSA code requirements in terms of structural performance (capacity, fatigue, durability and serviceability) …"

(*Note: Refer footnote 186 for more detailed analysis and statement of opinion*)

Fact 14[167] - March 12, 2013: Letter from PIC in response to IO letter of Mar 5, 2013–

[167] Letter WEMG dated March 12, 2013, attach; I.O. binder tab 48

Question - "…Please confirm how the QVE Certificate of Conformance and Retained Engineer's Statement of Compliance addressed welding. It is not self-evident where or how these statements address the quality of the tack-welding, or that it was done in accordance with project requirements." –

Reply - "According to the requirements outlined in PA, OPSS or CSA as well as per CSA W186 neither QVE or RE (Plant Engineer) shall perform welding inspections.

"Inspections are performed by the certified welder…"

(*Note: no independent inspection is done*). (*See Fact 2, 3 about QVE and RE at Freyssinet*)

"Tack welds are subject to visual inspection and visual verification of the adjacent reinforcement for any sign of damage.

If there are any issues observed, they are noted on the Rear Control Check List.

This check list is one of the documents listed on SoC as being reviewed by RE

The Rebar Control Check List is also reviewed by QVE and compared against the shop drawings approved by the designer… per SSP909S01 (October 2010) clause 909.04.02.06"

Visual inspection by the welder with no independent verification. See Fact 2, 3 above. The welder is not qualified to make engineering judgements on welding of structural reinforcement. The Rear Control Checklist is provided to the RE without independent engineering input.RE and QVE have no inspectors role see Fact 2, 3.

Question - "…Please provide the frequency and location of the tack welds and clarify the allowable minimum spacing of the tack welds as it applies to the top and bottom flange connections to the web reinforcing." –

Reply - "Tack welds are done as shown on shop drawings and detailed on the letter from our Designer, e.Construct dated 2/18/2013…The spacing of those welds is as followed:

- Maximum space on every reinforcement cage sheet connections with a maximum of 1.2m

- Minimum space every 6 wire spacing

The work is done under the supervision of the reinforcement foreman to comply with lifting operations."

Beam deconstruction has not corroborated this information.[168]

Question - "…Please provide a statement from the QVE/RE that states thetack welds were of acceptable quality." –

Reply – "… As such all the QC functions are performed by the F/TA production people."

Fact 15[169] - March 20, 2013: Information Outstanding –

2. "...are tack-welds, in fact, being done in a satisfactory way (given that HMQ staff have been at the fabrication facility and noted tack welding occurring in locations not shown on the fabrication drawings..."

4. "...are the welders and welding inspector qualified and the company performing the tack welding certified, all to CSA W186?"

6. "Related to Appendix 7 from the letter of February 28, we note the welds in Location 3 (between vertical wire of Type B WWR and longitudinal wire of Type D WWR in the girder bottom flange) Welding can reduce the

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[168] Transcript of interview with Freyssinet, August 28, 2013; page 111 line 15
[169] Letter I.O. dated March 20, 2013; I.O. binder tab 50

tensile capacity of the vertical legs and reduce the shear capacity of the girder, but the photographs provided in the letter do not clearly identify the frequency of these welds (although more information has been provided in this regard). The fabricator engineer should confirm that they have accounted for the frequency and quality of the welds, and the location and frequency of the welds should also be properly documented on as built drawings…"

(*Note: no records exist of tack weld quality and location*)[170]

Fact 16[171] - April 4, 2013: Works Committee meeting, section 4.0 –

8. Use of tack welds – "…HMQ claims current evidence suggests… there are also quality issues with the welds which means HMQ may have to challenge the Engineers opinion."

Fact 17[172] – April 23, 2013 CSA audit:

NCR#211 Use of Tack-Welds on Precast Girders and Use of Non-Qualified Welders (CSA W186) –

Details: "…It is also not apparent that the welding company is certified by Canadian Welding Bureau according to CSA W186."

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[170] Transcript of interview with Freyssinet, August 28, 2013; page 13 line 12
[171] Works Committee Meeting #26 dated April 4, 2013; IO binder tab 54
[172] Document NCR # 211, dated April 23, 2013; I.O. binder tab 59

Fact 18[173] – April 25, 2013: NCR#213 Precast Girder Plant Repair Procedure –

Details: "Per OPSS SP909S01 (October 2010) Clause 909.07.17.04 once the tack welds were identified as a deficiency there was no repair proposal related to the tack welds submitted to the Contract Administrator for review and acceptance. Per PA Schedule 15-2 Part 1 Article 1.1(a)(iv) PCo did not consult with HMQ about the repair proposal for the use of tack welds."

Fact 19[174] - From CSA audit:

May 13, 2013 OFI #78 – QVE sign-off on the Repair Sheets –

Description: "Repair Sheets were provided that showed the location of the repair in which the repairs are to be done in accordance with the repair procedure in the Quality Manual. The auditor did not find documentation that showed that the repairs were completed to the satisfaction of the Quality Verification Engineer..."

May 13, 2013 OFI #79 – Interim Inspections –

Description: "The Permission to Proceed Certificate and the Certificate of Conformance were provided as evidence. The certificates were dated one day

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[173] Document NCR # 213, dated April 23, 2013; IO binder tab 59
[174] Document OFI #78, OFI#79 dated May 13, 2013; OFI#85 dated May 14, 2013; IO binder tab 68

apart. There was no separate certificate for an interim inspection that would show when that inspection was performed for a particular beam..."

May 14, 2013 OFT #85 – Certifications and Licenses –

Description: "The October 11, 2012 precast documentation report was missing a welder's certificate."

Fact 20[175]- May 14, 2013: "Notice of Dispute regarding Freyssinet Girders"

Fact 21[176] – May 24, 2013: Letter from PIC –

2) Tack Welding – "PIE/HMM has provided the attached Technical Memo, dated May 24, 2013 (the "HMM Memo") which includes the following:

PIE analysis for Tunnel T-2 and Tunnel T-7 shows that ULS, FLS and SLS requirements of the Canadian Highway Bridge Design Code CAN/CSA-S6-06 (CHBDC) code would perform the same"

Fact 22[177] - May 31, 2013: HMQ Conditions Related to ProjectCo Technical Memo –

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175 Letter I.O. dated May 14, 2013; I.O. binder tab 69
176 Letter WEMG dated May 24, 2013, attach; IO binder tab 70
177 Letter I.O. dated May 31, 2013; I.O. binder tab 74

§4 3. "The updated Technical Memo shall include a sensitivity analysis, meaning engineering analysis to show the amount of vertical reinforcement that could be 100% cut through as a result of improperly tack welding before the girders would fail to meet the design requirements for ULS and/or SLS and/or FLS as per the CHBDC, for the girders used in tunnels T-2, T-3, T-5 and T-7."

Fact 23[178] – June 7, 2013: Letter from PIC with response to HMQ's list of conditions –

"The updated Technical Memo must be based upon the analysis and investigation noted above and any other analysis of investigation that HMM believes to be necessary…"

Response – Please find enclosed an updated Technical Memo from HMM including a Statement of Opinion.

4.2 Ultimate Limit States Analysis (Tunnels T2 and T7)

Non-Fire ULS Analysis conclusion: Results in Appendix A and B show sufficient capacity after welding for this design case.

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[178] Letter WEMG dated June 7, 2013; I.O. binder tab 76

Fire ULS Analysis conclusion: The design is considered satisfactory under the fire loads.

4.3 Fatigue Limit States Check (Tunnels T2 and T7)

For both tunnels SLS shear loading was found not to cause web-shear cracking. (Simplified method exceeds limiting stress but General method, more comprehensive, satisfies Code requirements)

4.4 Serviceability Limit States Check conclusion (Tunnels T2 and T7) -

Section remains uncracked at the weld location. (*Note: See Fig.3, 4 with tack weld spacing of 2 adjacent bars and 3 in 5 stirrups; Fact 27remarks that no obvious pattern was observed including 4 successive bars in a shear zone*)

5 Conclusion for 1.0 m Tack Weld Spacing (Tunnels T2 and T7)

(Note: Assumption of 100% section loss at weld)

PIE analysis shows that ULS, FLS and SLS requirements are met.

6 Analysis considering 1 out of 6 stirrups is welded conclusion –

At midspan 5 stirrup (1 in 6) spacing exceeds 1 m fatigue is not mode of failure.

In shear zones of girders with 1 out of 6 stirrups tack welded, still meet PA requirements.

(*Note: Fact 27field evidence is that spacing can be significantly smaller than 1 in 6*)

7. ULS sensitivity analysis on T-2 and T-7 number of welded stirrups conclusions

(*Note: Assumption of 100% section loss at weld*)

T2 girder type A1 – tack weld spacing closer than 1 in 6 stirrups girder fails.

T2 girder type A2, B2, B3 – tack weld spacing closer than 1 in 4 stirrups girder fails.

T7 – tack weld spacing closer than 1 in 5 stirrups girder fails.

Fact 24[179] – June 16, 2013: Letter from PIE/HMM with respect to –

Welding Quality

"Biljana Rajlic of HMM visited the Tierra Armada/ Freyssinet Canada plant on June 14, 2013 in Windsor to interview personnel involved in tack-welding and in girder inspection.

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[179] Letter WEMG dated June 16, 2013; I.O. binder tab 78

Considering the following information

- All the welders were qualified (although not specifically to W186 for reinforcing steel) from the beginning of girder production.
- The welders followed the welding procedure included in the Tierra Armada Quality System Manual from the beginning of production. This manual was used for CSA certification of the plant.
- Tierra Armada/Freyssinet hired an independent welding inspector company GS Inspection Consultants

  (*Note: for 4 days only August 2, 3, 7, 8 2012*).
- Information obtained in discussion with the welders, inspectors (*Note: any independent inspector?*) and supervisors, such as:
    - As part of the welding procedure, visual inspections were carried out, and no visual cracks or undercuts were found.
    - Welds touched less than 10% of the external face of the bar.

- Loss of vertical reinforcing bars (stirrups) due to possible microcracking could be 1% to 2%, plus additional maximum 5% loss due to cage handling.

- All welds were the correct size, indicating that heat was controlled during the welding process.

It is very unlikely to have a loss of section greater than 25% in the welded reinforcing bars. (*Note: see Fact 27 no justification for 25%*) This is similar to suggested values for regular welds calculations in CSA W186-M1990 (R2102) – Welding of Reinforcing Bars in Reinforced Concrete Construction document.

Based on the structural analysis carried out by HMM and reported (in summary) above and based on the information obtained during the HMM plant visit, it is our opinion that all girders for tunnels T2, T3, T5 and T7, meet the structural requirements of the Project Agreement Schedule 15-2 (CAN/CSA S6-06) and will perform equally as well as other girders produced to the same requirement." (*Note: see Fact 27*)

Fact 25[180] – July 15, 2013: "Technical Review of Statement of Opinion regarding Tunnels T2, T3, T5 and T7 NU Girders Reinforcement Cage Tack Welding"

CH2MHILL in a role of Technical Advisor to I.O. will undertake a technical review of the statement of opinion authored by Biljana Rajlic, P.Eng. of HMM (*Note: see Fact 23*)

> *"…Also ongoing is our assessment of the mitigating factors discussed by B. Rajlic with respect to weld quality and its impact on loss of section (i.e. factors leading to less than 100% section loss is assumed in bars at the tack weld locations in question is a conservative and sound approach to assessing girder compliance with the limit states criteria (ultimate, fatigue and serviceability) of the Canadian Highway Bridge Design Code."*

Fact 26[181] – July 28, 2013: "HMQ Request to Expose Tack Welds" –

§2 line 1 "First, we request that you provide us with a detailed procedure, for our Review, of how PCo will go about exposing the tack welds for inspection. The procedure should indicate how PCo will safely remove the concrete cover to expose the steel reinforcing and the tack welds …"

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[180] Letter CH2MHILL dated July 15, 2013; IO binder tab 82
[181] Letter I.O. dated July 28, 2013; I.O. binder tab 91

Fact 27[182] – July 30, 2013: "Technical Review of Reinforcement Cage Tack Welding on Tunnels T2, T3, T5 and T7 NU Girders"

§2 line 5 "…although the provision for and details of all the tack welding used was not indicated on the shop drawings. A concern has been raised by HMQ that the use of the tack welding may have reduced the capacity of the reinforcing steel at the weld locations…"

§7 line 1 "Location 2 is between transverse wire of Type C WWR and transverse wire of Type D WWR in the girder bottom flange.

This tack weld uses a lap splice, however, our examination of the photograph in Figure 3 (see Appendix A) of the e.Construct letter dated February 18, 2013 indicates the welding is in a location within the cold bend of the reinforcing bar which is not permitted under clause 6.9.2 (c) of CSA W186. The location of this tack weld does not appear on the fabrication drawings approved by the engineer responsible for the girder design. In Figure 3 photograph (see Appendix A), the spacing between tack welds appears to be 6 wire bar spaces."

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[182] Letter CH2MHILL, dated July 30, 2013; I.O. binder tab 93

§8 line 1 "Location 3 is between vertical wire of Type B WWR and longitudinal wire of Type D WWR in the girder bottom flange.

CSA W186 does not explicitly contemplate the use of this welding geometry, however under the provisions of clause 6.3.1, the use of other bar splice arrangements are allowed if permitted by the engineer responsible for the structure.[183]

The vertical wire of the Type B WWR has a primary role in carrying shear forces in the girder and would be considered a region of high stress. CSA W186 clause 6.9 identifies permitted configurations and configurations not permitted for tack welds. In our opinion, tack welding to the vertical wire of Type B WWR fails to comply with the clauses' restriction on tack welding in regions of high stress.

The location and detail of this tack weld does not appear on the fabrication drawings approved by the engineer responsible for the girder design.

In Figure 3 photograph (see Appendix A), the spacing between tack welds at the girder ends appears to be every six vertical bars."

[183] Franck Chavent claims that he obtained permission for the tack weld - Transcript of interview with Freyssinet, August 28, 2013; page 88 line 2.

§11 line 1 “Location 4 is between transverse wire of Type A WWR and longitudinal wire of Type B WWR in the girder top flange.

Our examination of the photographs in Figure 5 (see Appendix A), shows this configuration of tack weld to also be a weld of two bars crossing, that would only be allowed if permitted by the engineer responsible for the structure.”

The transverse wire of the Type A WWR has a primary function in carrying construction live load from the deck pour. In our opinion, tack welding of the transverse wire of Type A WWR fails to comply with the CSA W186 clause 6.9 restriction on tack welding in regions of high stress.

The location and detail for this tack weld does not appear on the fabrication drawings approved by the engineer responsible for the girder design…”

§14 “Review and Assessment of Welding and Weld Quality Records –

Reinforcing bars generally have a higher carbon and manganese than normal structural steel, and are generally considered to be more susceptible to cracking from improper welding. The pertinent concrete construction codes consider it important that reinforcing bar welds are properly located and detailed and that standards in weld quality be met. In this regard, we have

observed inconsistencies and generally poor records in the documents provided with respect to welding matters related to the girders in question."

§15 line 1 "Except for location 1, we note the absence of specification of the size, length and location of tack welds on the fabrication drawings approved by the engineer responsible for the girder design as required under CSA W186 clause 7.1.4. Other than what is apparent in the limited number of photographs made available to us, the only written documentation of tack weld spacing is within an April 22, 2013 e.Construct letter discussing the concern with location 3 wherein Tierra Armada indicates tack welding was generally undertaken at one metre spacing."

§16 line 1 "Location 3 and 4 use a tack weld geometry (bars crossing or Tee) that CSA W186 does not explicitly address. In order to better ascertain if the use of the bar crossing welding is a concerning factor, we undertook some discussion with both the Canadian Welding Bureau, who administers CSA W186, has indicated to us that their practice is to receive, review, and approve as appropriate, welding procedures for bar crossing geometry for tack welding purposes only, submitted by the engineer for the company that performs the welding.

The equivalent U.S. standard to CSA W186, namely ADS D1.4 'Structural Welding Code – Reinforcing Steel', contains a provision which states, "4.2.5 Welding of bars which cross shall not be permitted unless authorized by the Engineer". Our enquiries through AWS, returned a consensus opinion from several members of the D1.4 committee that the inherent difficulty in achieving a satisfactory weld for this joint geometry is the primary reason for the prohibition…"

The Welding Procedure Data Sheets approved by CWB includes a procedure for a tack weld of bars crossing. The Welding Procedure Data Sheet bears the seal of a registered professional engineer, in this context commonly referred as the welding engineer. As is often the case, this engineer is different from the registered professional engineers that seal the girder fabrication drawings."

§20 line 1 "Considering the above, we see no documented evidence that the engineers responsible for the girder design were aware of and approved the use of tack welding at locations 2, 3 and 4. In our opinion, the location and arrangement to weld to bars that have a primary function in carrying load is not appropriate based on failure to comply with clause 6.8 of CSA W186."

§21 line 1 "Given that use of tack welds at location 2, 3 and 4 in high stress locations appears to not have been approved by the engineers responsible for the girder design as required by applicable codes, we find it of paramount importance in making an informed judgement on the impact of the tack welding undertaken, that there be weld quality records to demonstrate the quality provisions under clause 7.5 of CSA W186 have been met, in particular that undercutting was within specified limits. We have not been provided with quality records on the tack welding undertaken at locations 2, 3 and 4 and it is our understanding such records do not appear to exist."

§23 line 1 "The Welding Procedure Data Sheets approved by CWB specify the welding procedure is for base metal that conforms to CSA G30.18 400W… We reviewed mill certificates provided to us for tunnels T2 and T7 which identifies the Type B WWR at location 3 was manufactured in accordance with ASTM A1094 (?) and ASTM A497, respectively. These two ASTM standards allow WWR to be manufactured from any number of ASTM wire or bar standards. The information provided to us indicates the vertical wire of Type B WWR for T7 was rolled to ASTM A510 standard, not the CSA G30.18 400W expected in the Welding Procedure Data Sheets. The vertical wire of Type B WWR for T2 is purported to also be ASTM A510…The chemical

composition data provided for ASTM A510 for T7 indicates that the wire satisfies clause 5.1(b) and therefore is permissible to be fusion welded under CSA W186."

§25 "Assessment of Each Tack Weld Location –

Location 1

We received and reviewed a single inspection …record conducted by GS Inspection Consultants, a CWB certified welding inspection company. The inspection record was marked as girder A1 on tunnel T7 … the tack welds were not within 10mm of the ends of bar as required in the fabrication drawing detail and which we note is a requirement under CSA W186 clause 6.9.1 (ii).

As well, the base metal being welded is not CSA G30.18 400W as expected in the approved Welding Procedure Data Sheet.

Despite these anomalies, we concur with the e.Construct letter dated Feb 18, 2013 concluding that location 1 tack welds are in areas that do not have a negative impact on structural performance of the girders."

Location 2

"…indicates that the tack welding at location 2 has not adversely affected performance."

Location 3

"…is a location that will encounter high stress under loading and the vertical bars at the tack weld point are required for structural strength.

For these reasons, it is our opinion that nothing less than 100% section loss at location 3 should be assumed in assessing the impact to the girder performance. The initial step of the analysis…undertaken in the PIE/HMM technical memorandum dated Jun 7, 2013 makes this 100% section loss assumption which we concur with."

Location 4

"The same issues identifies for location 3 are pertinent to location 4…We were not provided with any records or photographs that indicate what the spacing of the tack welding was at location 4.

We reviewed the analysis of location 4 in the e.Construct letter dated Feb 18, 2013. Their analysis assumes every transverse wire of the Type A WWR was

tack welded and that 100% section loss occurred. In examining the analysis conducted, we felt additional checks were necessary."

§35 Review of Location 3 Analysis – The critical location from a strength and durability perspective is location 3 which is the subject of the PIE/HMM technical memorandum and statement of opinion and three e.Construct letters dated February 18, April 22 and May 8, 2013. We focused our review on the comprehensive analysis provided in the PIE/HMM technical memorandum dated June 7, 2013. The initial methodology in the PIE/HMM technical memorandum has been to assume 100% section loss at the tack weld at location 3…we believe this is an appropriately conservative and sound approach to assessing the girder compliance…"

§39 "Consideration of Potential to Have Less Than 100% Section Loss at Location 3 – B. Rajlic's concluding opinion…that the girders satisfy the requirements of the Project Agreement, relies upon an assessment that greater than 25% section loss was unlikely. Limiting section loss to 25% means all girders would perform satisfactorily, including any girders with tack welding at location 3 more frequent than one in six stirrups that PIE/HMM's analysis showed requires something less than 100% section loss. The PIE/HMM discusses what we would characterize as mitigating factors that in B. Rajlic's

opinion suggest some assurance of nominal weld quality enough for her to conclude likely no more than 25% section loss. In our opinion, the points B. Rajlic raises are unconvincing in this regard.

- "*All welders were qualified (although not specifically to W186 for reinforcing steel) from the beginning of girder production*" – the pertinent and detrimental factor is the welders were not qualified to weld reinforcing bars.

- "*The welders followed the welding procedure included in the Tierra Armada Quality System Manual from the beginning of production. This manual was used for CSA certification of the plant*." – we observe a lack of evidence to prove this statement. And in fact, the welding of base metals that were not part of an approved welding procedure, evidences quality procedures were not being complied with.

- "*Tierra Armada/Freyssinet Canada hired an independent welding inspection company GS Inspection Consultants*." – the information we have from our client who have spoken with GS Inspection Consultants, is that they inspected 12 cages of reinforcing in early August 2012 at the commencement of girder production and then their contract ended.

They were not asked to return until April 2013. Thus there appears to have not been ongoing independent verification of weld quality throughout the production run.

- Regarding information B. Rajlic obtained in discussion with welders, inspectors and supervisors:

  - "*As part of the welding procedure, visual inspections were carried out and no visual cracks or undercuts were found…welds touched less than 100% of the external face of the bar…all weld were the correct size, indicating heat was controlled during the welding process*" – in absence of documented evidence that visual inspections were being undertaken, we consider this information to be hearsay and not something we are prepare to rely upon in making our engineering judgement.

  - "*Loss of vertical reinforcing bars (stirrups) due to possible microcracking could be 1% to 2%, plus additional maximum 5% loss due to cage handling*" – presented without elaboration or reference to standards or literature in the industry, we are unclear on the

technical validity of this statement and how these percentages have been arrived at.

With the above in mind we cannot find a compelling argument to conclude that weld quality provisions of CSA W186 have been met consistently in the girder production run to the point of opining residual capacity in the order of a maximum 25% section loss."

This leads us to conclude that in the case where tack welds at location 3 occur in a girder every 6 stirrups of greater (one tack weld every 450 mm or greater), the girders should perform as expected under the CAN/CSA S6-06 and the project design criteria.

However, if the actual fabrication was done with more frequent tack welds of 1 in 5 stirrups or less (one tack weld every 375 mm or less), then the girder would not meet these criteria in the most exceptional circumstance, namely the fire load design case.

To be clear, we are not concluding that girders will not perform adequately under the exceptional fire design load case. There may very well be sufficient residual capacity in tack welds in any given girder, but the absence of quality records that could demonstrate consistency in weld quality does not allow us

to unequivocally say all girders in the production run will perform as expected."

§45 "Recommendations –

As we noted earlier, if the spacing of tack welds at location 3 is one in 6 stirrups or greater (one tack weld per 450 mm or greater), then analysis shows residual section capacity at the tack weld locations need not be relied upon to satisfy the exceptional fire design load case criteria. Therefore, if this tack weld spacing can be confirmed by records or some physical evidence, then our caveat on expected performance can be removed and we would be in a position to concur with the PIE/HMM statement of opinion that the girders meet the structural requirements of the Project Agreement and the Canadian Highway Bridge Design Code in all load cases.

Also confirmation of the tack weld spacing at location 4 would provide greater certainty with respect to the performance of the girder top flange.

In the absence of records, we recommend obtaining physical evidence of the tack weld spacing."

Fact 28[184] – August 27, 2013: "Tack Welding on Tunnels T2, T3, T5 and T7 NU Girders – Destructive Testing and Remedial Measures" –

§2 "The first deconstructed production girder, B-12 slated for tunnel T-7, does not show a consistent pattern of tack welding at one in six bars in the girder ends as hoped. Tack welding follows no obvious pattern and generally shows tack welded stirrup bars occurring at less than one in six bars including on one side of the girder four adjacent stirrup bars in the girder end zone where shear forces are high and stirrup bars are more closely space at 75 mm. Tack welding frequency increases moving towards the centre portion of the girder."

§3 "Deconstruction of production girder, B-60 slated for tunnel T-7 is not yet completed, but as of this writing exhibits some tack welds in the 75 mm end zone at a frequency of less than one in six stirrups."

§4 "These early results suggest a different line of engineering analysis is needed to demonstrate strength, serviceability, and fatigue provisions of CHBDC are satisfied, than that provided in the June 16, 2013 Statement of Opinion by HMM. The June 16 HMM analysis is based upon the expectation

[184] Letter CH2MHILL dated August 27, 2013; IO binder tab 97

of a regular tack weld pattern, wherein every tack welded stirrup (1 in "x" stirrups) is discounted altogether or has a reduced capacity (*Note: in the 75 mm end zone non-uniform distribution would cause wider rotation at shear crack and possible sudden brittle failure*). This particular design check is not for the tack welding patterns being observed. Instead, an alternative approach would be a design check analysis that considers measured stirrup capacity results from test samples to determine a single statistically (*Note: what sample size for 203 girders*) safe f_y value to be applied to all stirrups in the girder. We elaborate on this approach below."

§6 Summary of paragraph - Testing stirrup steel ductility, tensile strength (chemical and microscopic analyses) for revised analysis.

§7 Summary of paragraph - Test tensile strength of stirrup steel to evaluate statistically a 'safe f_y value' for further analysis of stirrup capacity.

§8 Summary of paragraph - If adjusted shear capacity of girder is insufficient then remedial measure with fibre reinforced polymer (**"FRP"**) can be applied.

(Note: FRP has to be dimensioned for the amount of resistance required. However, not having the datum resistance, the FRP requirement cannot be calculated. Girder resistance is likely very different.)

§9 Summary of paragraph – there exist coatings for application to FRP sheets which can provide up to 4 hour UL fire rating.

Fact 29[185] - Photographs accompanying NCR#102 – "Repair of deficiencies on girders produced by Tierra Armada", dated August 2012 show defects such as voids, honeycombing, air pockets, delaminations and corner cracks on beams A1, A2, A9, A11 and A12. Under "Details" the report reads "Use of un-approved material for repair of deficiencies. As per PIC Quality Management System, all material shall be submitted for approval before to start the use of it. OPSS SP909S01 repair methods stated in Table 3 were not followed." This report concerns the very first girders manufactured so it cannot be said to be representative of all production to May 23, 2013

Freyssinet defended the use of tack welding by stating that the location of tack welds was done strategically and that approval had been obtained from ProjectCo.[186]

[185] NCR#102 dated August 27, 2012; I.O. binder tab 01
[186] Transcript of interview with Freyssinet, August 28, 2013; page 88 line 2, page 89 line 20, page 90 line 5, page 111 line 15

Applicable Codes and/or Standards

Project Agreement – Schedule 15-2 -

PART 1 GENERAL PROVISIONS - ARTICLE 1 REFERENCE DOCUMENTS

1.1 **Application of Ontario Provincial Standards for Roads and Public Works and MTO Technical Manuals**

a) The Works shall be carried out in accordance with Ontario Provincial Standards for Roads and Public Works (OPS) and other applicable Reference Documents, including MTO Technical Manuals, subject to Section 1.3 [Order of Precedence] of this part and with the following amendments to OPS and MTO Technical Manuals:

(i) OPS and MTO Technical Manuals requirements related to design and submission requirements and quality assurance do not apply; rather, The Design and Construction Specifications and Schedule 11 – Quality Management of this Project Agreement respectively shall apply:

1.3 **Order of Precedence**

(a) Unless otherwise expressly provided in this Schedule, …

PART 2 DESIGN AND CONSTRUCTION REQUIREMENTS - ARTICLE 3 STRUCTURAL DESIGN CRITERIA

3.1 **Order of Precedence**

(a) The design and construction of Structures shall be in accordance with the criteria contained in this Article and the following Reference Documents, and if there is any conflict between the criteria contained in this Article and any Reference Document(s), the following shall apply in descending order of precedence for design and construction of Structures:

(i) The criteria contained in this Article;

(ii) CAN/CSA-S6-06; except Structural Manual: Division I Exceptions to the Canadian Highway Bridge Design Code [CHBDC]

(iii) Structural Manual;

(iv) Geometric Design Standards for Ontario Highways (MTO);

(v) Roadside Safety Manual;

(vi) NFPA 502 [National Fire Protection Association];

(vii) OPS [Ontario Provincial Standards];

(viii) MTO Manuals;

(ix) DSM [Designated Source for Materials]; and

(x) MTO Reports and Guidelines

General Requirements

(c) "Checking of Structural Design"

1. "Project Co shall engage an independent Checking Team, the qualifications of which are in Section [20.7] of the Project Agreement, to perform design check of Structures, which are significant and complex structures and include for example Tunnels, … structures that require sophisticated analyses, unconventional designs, spans exceeding 20 m …"

   A. conducting design checks to ensure that the design of Structures meets performance expectations

outlined in this Project Agreement and that such design is carried out according to accepted industry standards;

B. undertaking supplementary analyses to independently verify and confirm the appropriateness of design methodologies and assumptions used; and

C. identifying deficiencies in the design and analyses, and satisfying Project Co and the HMQ Representative of unresolved deficiencies.

Project Agreement – Schedule 15-1 Part 1 provides Definitions and Part 2 Reference Documents. Specifically to this report the following Codes and Standards are referenced in the documentation with respect to tack welding of the girders in the Project.

Ontario Provincial Standards:

OPSS 905 - Construction Specification for Steel Reinforcement for Concrete

OPSS 909 - Construction Specification for Prestressed Concrete – Precast Members

OPSS 1440 - Material Specification for Steel Reinforcement for Concrete

OSIM [Ontario Structure Inspection Manual]

Canadian Standards Association:

CAN/CSA – A23.4-09 - Precast Concrete - Materials and Construction

CAN/CSA – G30.14-M1983 – Deformed Steel Wire for Concrete Reinforcement

CAN/CSA – G30.15-M1983 – Welded Deformed Steel Wire Fabric for Concrete Reinforcement

CAN/CSA – G30.18-09 - Carbon steel bars for concrete reinforcement

CAN/CSA - G40.20-13/G40.21-13 - General requirements for rolled or welded structural quality steel / Structural quality steel

CAN/CSA – S6-06 – Canadian Highway Bridge Design Code

CAN/CSA - W47.1-09 - Certification of companies for fusion welding of steel

CAN/CSA - W59-03 (R2008) - Welded Steel Construction (Metal Arc Welding)

CAN/CSA - W186-M1990 (R2012) - Welding of Reinforcing Bars in Reinforced Concrete Construction

American Standards:

A1064/A1064M (2012) - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM A497 (2001) – Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

ASTM A510 (2008) – Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

AWS D1.4 (1998) – Structural Welding Code – Reinforcing Steel

Implications Insofar as Safety and Durability of Girders are Concerned

Safety – The CAN/CSA S6-06

The CAN/CSA S6-06 sets out fundamental principles, and 'Safety' is identified as the overriding concern. It is fundamental to understand that faultless compliance with the CAN/CSA S6-06 results in a structure with probably the lowest risk of failure in our current state of knowledge.

For new structures, fatigue is perhaps a more important safety consideration than ultimate strength or excessive deflection, cracking or vibration, because it is a potential cause of sudden and catastrophic failure. The reliability index in the Code which is a measure of structural safety ensures that components will not fail abruptly or will retain post-failure capacity, and that the new bridge will not collapse suddenly. The Code aims for a structure design life of 75 years.

The safety and durability of any bridge structure is unequivocally linked to the quality of every step of the process to undertake an engineering project from concept, design, manufacturing, construction, commissioning and last but not least appropriate maintenance throughout the service life.

Safety – Tack Welding

It is evident from the history of 'Facts' listed above, that Freyssinet and their QVE/RE were not aware of or possibly not qualified to know the potential risks associated with tack welding of structural reinforcement subjected to high stress due to cyclic loading. It is equally a fact that the importance of the CAN/CSA S6-06 was not as determinant as it should have been in the preparation of shop drawings and also when the Technical Advisor to ProjectCo expressed in writing that tack welding should be discouraged.

Since December 2012 significant effort has been made to determine the possible consequences of unauthorized tack welding mostly based on unproven information since records did not exist. Forensic deconstruction of selected girders has been undertaken and the results, still incomplete, enable a better appreciation of the most likely effects of tack welding of the girders for the Parkway.

It has now been confirmed that tack welding in the girders does not conform to a regular pattern particularly in the girder zones where shear strength is critical. The variation in frequency of tack welding in these critical zones ranges from potential failure to acceptable. Extensive testing of the reinforcement affected by tack welding has so far yielded satisfactory results

although the latest set of tests reviewed (September 25, 2013) appear to have a higher rate of tensile strength failures due to the tack weld.

Notwithstanding all efforts being made to rationalize the most likely deviation in safety from the CAN/CSA S6-06 requirements, the scatter in results observed from forensic deconstruction and production quality control has not improved the degree of engineering certainty on the safety of the 500 girders produced.

Conclusion: It is irrefutable that tack welding of structural reinforcement for bridge structures is 'discouraged' and only the design engineer can assess its potential impact on the project. Variance from the CAN/CSA S6-06 must therefore be pre-approved. Tack welding of the Parkway girders was done without record and the evidence from forensic testing confirms the uncertainty with respect to their safety and durability.

Safety – Means and Method

During the presentations and interviews given to the IERC tack welding was justified as a "Means and Method" practice commonly used by Concrete precasting manufacturers. "Means and Method" is a physical change to the reinforcement cage of an engineering designed structure. As such it must be

sanctioned by the responsible design Engineer to ensure that the integrity of the design for compliance with the regulatory Codes has not been unacceptably altered. It is therefore evident that the practice "Means and Method" must always be used with utmost discernment. This was not the case with the girders for the Rt. Hon. H. Gray Parkway. It is evident that Freyssinet failed to recognize the level of competence necessary in this application.

Conclusion: No procedure justifies altering a professionally prepared and approved shop drawing without the express authorization of the Engineer responsible for the project. Independent inspection could have avoided this risk.

Safety – Quality Management System and Certificates of Compliance and Conformance

Quality Assurance and Control have been done by Freyssinet/Tierra Armada's in-house personnel. There is irrefutable evidence that Freyssinet Quality Control has fallen short of the project needs. Contrary to Freyssinet claim that QVE/RE roles were 'independent' evidence does not corroborate

this claim since their roles were entirely clerical without the benefit of an independent inspector's competence.

The quality and reliability of any Quality Management System is only as good as the soundness of the information input. Independent review of all input data is essential.

There are also serious concerns with the integrity of girders which have signs of cracking. The Technical Advisor to IO informed that casual observation of 9 girders for T5 and T7 stored at the Freyssinet plant displayed significant cracking at the ends (letter from I.O. Technical Advisor dated August 28, 2013). These cracks could have serious consequences for durability.

Conclusion: It is indispensable to have independent inspections and competent scrutiny of the Quality Assurance program.

Safety – Structural Analyses to CAN/CSA S6-06

The potential risk to safety of the girders due to tack welding at the different Limit States according to the CAN/CSA S6-06, was done. Since records of tack welds do not exist, sensitivity analysis of each girder type on tunnels 2 and 7 was done for different tack weld locations in the shear critical area. A

conservative and prudent approach was taken on available tack weld location patterns with 100% ineffective tack weld stirrups.

Tunnel(s) [beam type]	**No of girders**	**Stirrups omitted**	**CHBDC Limit States**			**Beam Safety risk**
			ULS	**FLS**	**SLS**	
T2 and T7	203			√		No web shear cracking
T2 and T7	203				√	Uncracked at level of weld
T2 and T7	203	1 m apart	√	√	√	SAFE
T2 and T7	203	Every 450mm {1 out of 6}	√	√	√	SAFE also for fire loading
T2 [A1]	2*	450mm or less {more than 1 in 6}	√			**UNSAFE**
T2 [B2, B3]	50	300mm or less {once every 4}	√			**UNSAFE**
T7	153	375mm or less {once every 5}	√			**UNSAFE for fire loading**

'*' cast after Nov 19, 2012

All 500 girders fall into one of the categories in the table.

The table says that for girder type A1 in T2 if more than 1 in 6 stirrups is omitted (because it is tack welded) the girder at the Ultimate Limit State is unsafe. If the number of welded stirrups is 1 in 5 stirrups or more then the girder would not meet Code requirements under exceptional case of fire load.

<u>Safety – Observation on the Methodology of Analysis</u>

In the shear analysis presented by ProjectCo, it was assumed that the spacing of stirrups can be increased to discount some of the stirrups affected by tack

welding. Thus 1 stirrup discounted in 6 would increase spacing by about 20%. This assumption is unsafe in cases where a tack welded stirrup does not function as intended because the stirrup spacing in that zone would double rather than increasing by a small margin as assumed in the analysis.

Furthermore when brittle stirrups (due to tack welding) break an impulse force is produced in addition to load shedding which may contribute to progressive collapse. The unusual situation of discontinuous shear tensile resistance is one more reason to justify a cautious interpretation of the standard analytical methods available.

Summary of Implications for Safety

The following conclusions may be drawn from the evidence available:

- Compliance with CAN/CSA S6-06 was not met
- The number of girders and the extent to which they might have been affected by tack welding is unknown
- It is not possible to define a characteristic baseline girder
- Risk tolerance is low because of the possibility of loss of lives associated with structural collapse

- Dependence on signs of distress during service life of girders as mitigating argument is not prudent as inspections can be unreliable and difficult

- The most cost effective time to mitigate uncertainty about safety is now

- Uncertainty on safety is highly undesirable for the Owner

Summary of Implications for Durability

Bridges are subjected to a hostile environment and repeated impact loading. Bridges and tunnels must not only withstand freezing and thawing but artificial cycles of weathering and chemical attack, through the use of deicing chemicals. Good quality high strength air-entrained precast prestressed concrete has excellent resistance to freeze thaw and chloride attack. The tunnel-ceiling girders have enhanced fire resistance provided by a sacrificial cover to reinforcement with a high strength polypropylene fiber added concrete mix. It is therefore reasonable to assume that the original design concept has accounted for the needs of a durable structure. Nevertheless some concern remains for reasons already discussed under Quality Assurance and Quality Management above.

Conclusion: Durability will be affected if the worst scenarios due to tack welding and concrete finish quality are not mitigated at the beginning of service life. Good maintenance and prompt repair of deterioration will also play a major role in the overall durability of the structure over 75 years.

Conclusion

- The safety and durability of certain 500 Freyssinet girders is uncertain.
- The risk of not achieving the objectives of the Project Agreement cannot be assessed.
- Durability of the girders is highly dependent on the maintenance during the girders' service life.
- Salvage of some girders might be possible, provided that:
    - Rigorous criteria for 'salvageability' of girders are designed
    - Acceptability of a "salvage" alternative by the stakeholders
    - Recognition of a higher risk maintenance service life

DURABILITY AND LONG-TERM PERFORMANCE

Introduction

In Ontario, given the cold weather and the use of deicing salts on roads, bridges and tunnels are subjected to the effects of dynamic traffic loads, corrosion, and freeze-thaw cycling. Ensuring the safety and durability of these critical transportation infrastructure systems presents major challenges for owners and managers. These challenges can be met through effective life cycle design, good quality construction and asset management, which can minimize the life cycle costs. In the case of the design of durable precast prestressed concrete bridges, the major parameters that affect the long term performance of bridge include: (i) Quality of construction; and (ii) Compliance with the code in terms of satisfying the serviceability, ultimate and fatigue limit states.

The CAN/CSA S6-06 does not allow the use of tack welding of reinforcing bars as it can reduce their fatigue resistance. Bars subjected to high stress under service loading are critical to the safety and durability of a bridge. Using unauthorized tack welding constitutes non-compliance with the Project Agreement (Schedule 15-2). This is the main reason why many North

American and international design codes and standards restrict the use of tack welding without a written approval from a regulatory authority.

In this section, the focus is on the impact of tack welding on the durability and long-term performance of precast prestressed concrete girders. This includes the corrosion risk and the fatigue resistance of the reinforcement.

Facts

This review concerns the durability and long-term performance of 500 girders fabricated between August 7, 2012[187] and May 23, 2013 for which tack welding was used. The information obtained by the IER Committee through various interviews and documents is chronologically presented in earlier sections. This section presents the facts that are closely related to the durability of the girders, while the facts related to tack weld locations, quality control, etc. are also presented in the earlier sections of this report.

Fact 1 – Concrete cover thickness for steel reinforcement: The girders of the tunnels are designed for fire load with an additional 30 mm sacrificial concrete cover all around. Figure 1 shows typical dimensions and typical

[187] Minutes of meeting #22 section 4.0 TA §1, date November 01, 2012; I.O. binder tab 09

reinforcement of a girder from tunnel T2[188] and Figure 2 shows typical dimensions and typical reinforcement of a girder from tunnel T3[189]. Both figures show thick concrete covers, which vary from 80 mm to 110 mm. The reinforcement details show that the concrete cover thickness at the four tack welding locations could be higher than 110 mm. The concrete is reinforced with high strength polypropylene fibers to reduce the cracking given the thick concrete covers.

Fact 2 – Girder end cracks and prestressing strand misalignment: On August, 28, 2013, CH2MHill reported[190] that their engineer observed thru cracks cutting through the width of the girder web. Some cracks are horizontal, while others are inclined and some girders have patched cracks. CH2MHill recommended the design to be checked and a proposal of remedial measures to be taken if necessary. CH2MHill engineer (with other personnel from MTO) observed that when hydro-demolition advanced to the mid-span region of B12, some of the prestressing strands within the girder appeared misaligned. Some strands rather than maintaining the strict 50 mm grid

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188 T2-IFC Calcs, pp 11, from ProjectCo soft version: Technical\Drawing and Calcs\T-2 HMM_Calcs.

189 E-Construct, Sheet S2319-A, from ProjectCo documents, soft version: Technical\Drawing and Calcs\E-Construct_IFC_Drawings- TAB-3 Drawings.

190 CH2MHill letter on Aug, 28, 2013: Tunnels T2, T3, T5 and T7 NU Girders – Field Observations on girder End Cracks and Prestressing Strand Misalignment.

spacing pattern shown on the shop drawings, were observed to be touching each other and crossing over each other[191].

Fact 3[192] - Photographs accompanying NCR#102 – "Repair of deficiencies on girders produced by Tierra Armada", dated August 2012 show defects, such as voids, honeycombing, air pockets, delaminations and corner cracks on beams A1, A2, A9, A11 and A12 under "Details" the report reads "Use of un-approved material for repair of deficiencies. As per PIC Quality Management System, all material shall be submitted for approval before its use. OPSS SP909S01 repair methods stated in Table 3 were not followed." This report concerns the very first girders manufactured so it cannot be said to be representative of all production up to May 23, 2013.

Fact 4 – The tensile test procedure of tack welded rebars performed by Acuren Group measures the tensile strength only[193]. The tests were performed without measuring the strain and the stress-strain relationships of tack-welded rebars are not plotted.

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191 CH2MHill letter on Aug, 28, 2013: Tunnels T2, T3, T5 and T7 NU Girders – Field Observations on girder End Cracks and Prestressing Strand Misalignment.

192 NCR#102 dated August 27, 2012; I.O. binder tab 01

193 Acuren Group Inc. Report/ file No 605-9296. Effect of field "tack welds" on tensile properties of MD 130 wire used in girder reinforcing steel cages. August 14, 2013.

Fact 5 – The ductility of tack welded rebars and their fracture energy at different temperatures have not been evaluated (e.g. using Charpy V notch test as per ASTM 370).

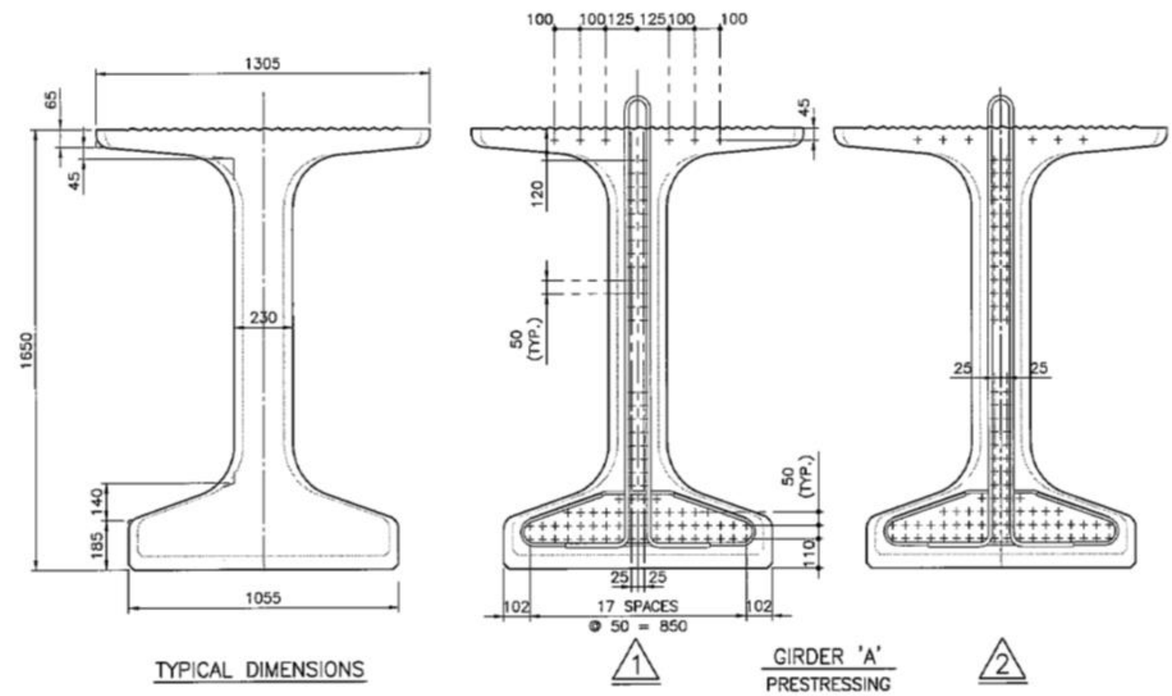

Figure 1: Typical dimensions and typical reinforcement of a girder from Tunnel T2
(from PIC soft version: Technical\Drawing and Calcs\T-2 HMM_Calcs)

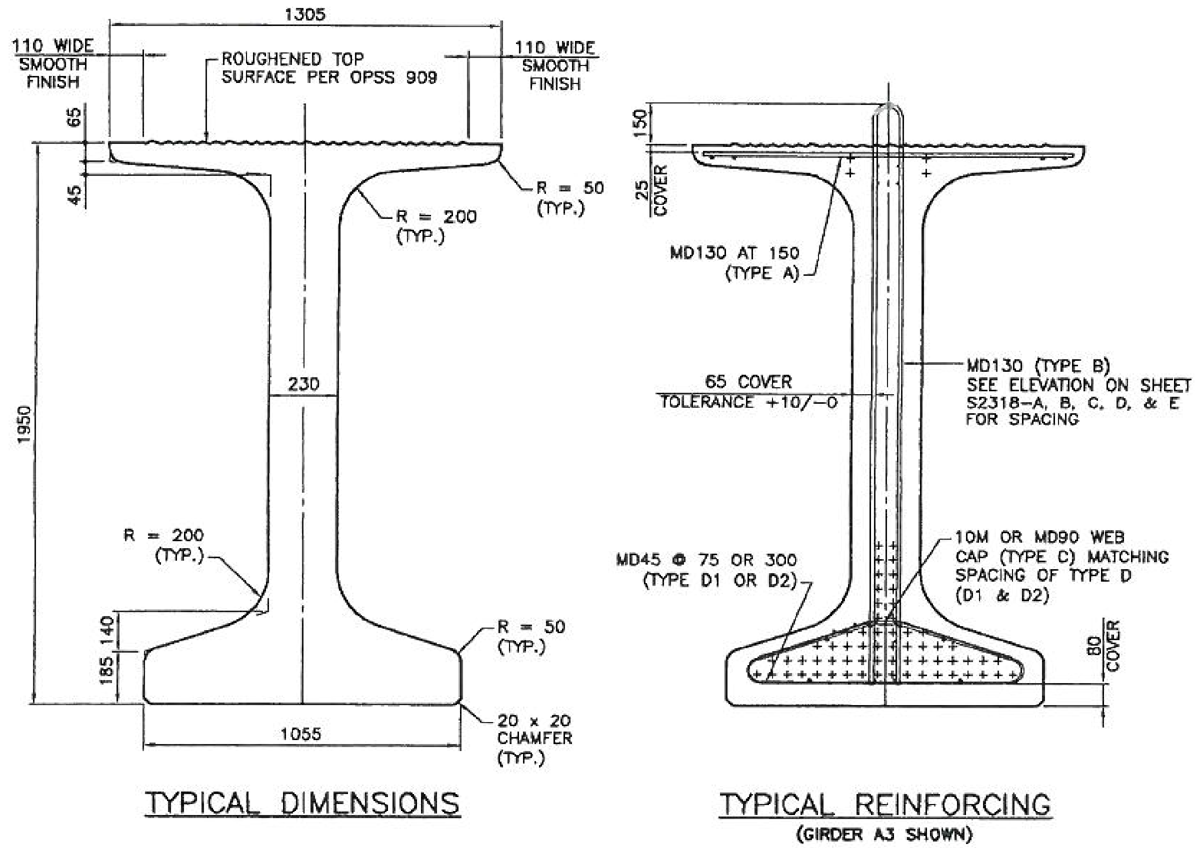

Figure 2: Typical dimensions and typical reinforcement of a girder from tunnel T3 (from PIC soft version: Technical\Drawing and Calcs\E-Construct_IFC_Drawings- TAB-3 Drawings)

Implications for durability and long term performance of Girders

Concrete Cover and Tack Welding Impact on Durability

The girders were designed with concrete covers for non-prestressed steel that varied from 80 mm to 110 mm. The concrete is reinforced with high strength polypropylene fibers to reduce the cracking given the thick concrete covers.

The service life and specifically the time to onset of corrosion of reinforced concrete structures built in a chloride-laden environment is governed by the concrete cover thickness, chloride diffusion coefficient, which depends on the concrete quality (permeability), and chloride threshold level, which depends on the type of reinforcing steel. Under the assumption of a diffusion mechanism for chloride ingress into concrete girders, the relationships such as those shown in Figure 3[194] can be used to identify the most relevant parameters and serve as a guide for service life design of concrete structures. For conventional carbon steel, the time to corrosion initiation is found to be most sensitive to concrete cover depth, followed by chloride diffusion coefficient[195]. For corrosion-resistant steels, the time to corrosion initiation is most sensitive to the surface chloride concentration and chloride threshold level followed by the concrete cover depth and chloride diffusion coefficient (see Figure 4)[196].

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194 Zhang, J., Lounis, Z., "Nonlinear relationships between parameters of simplified diffusion-based model for service life design of concrete structures exposed to chlorides", Cement & Concrete Composites. 31, 2009, pages 591–600

195 *Ibid*.

196 *Ibid*.

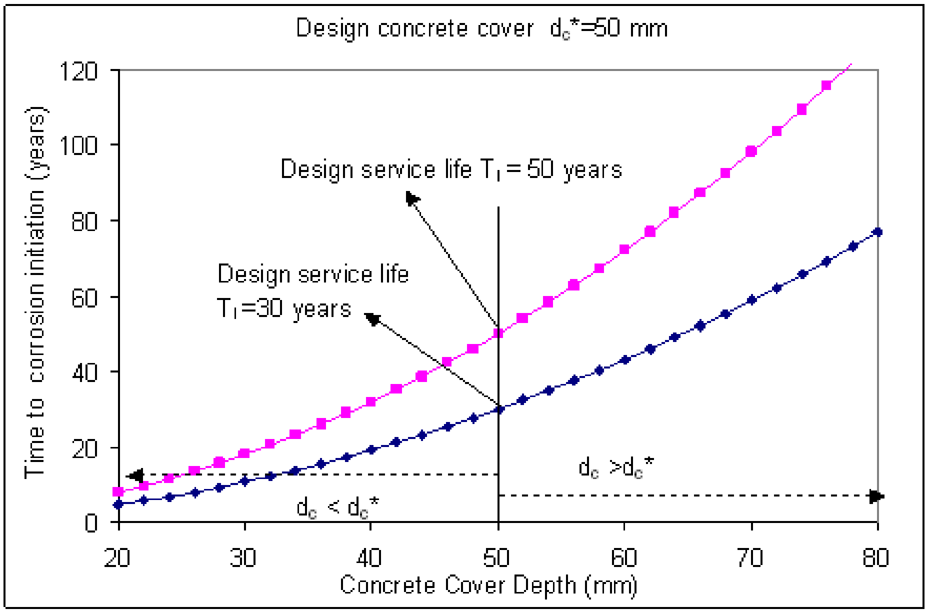

Figure 3: Time to corrosion initiation for various concrete cover thicknesses

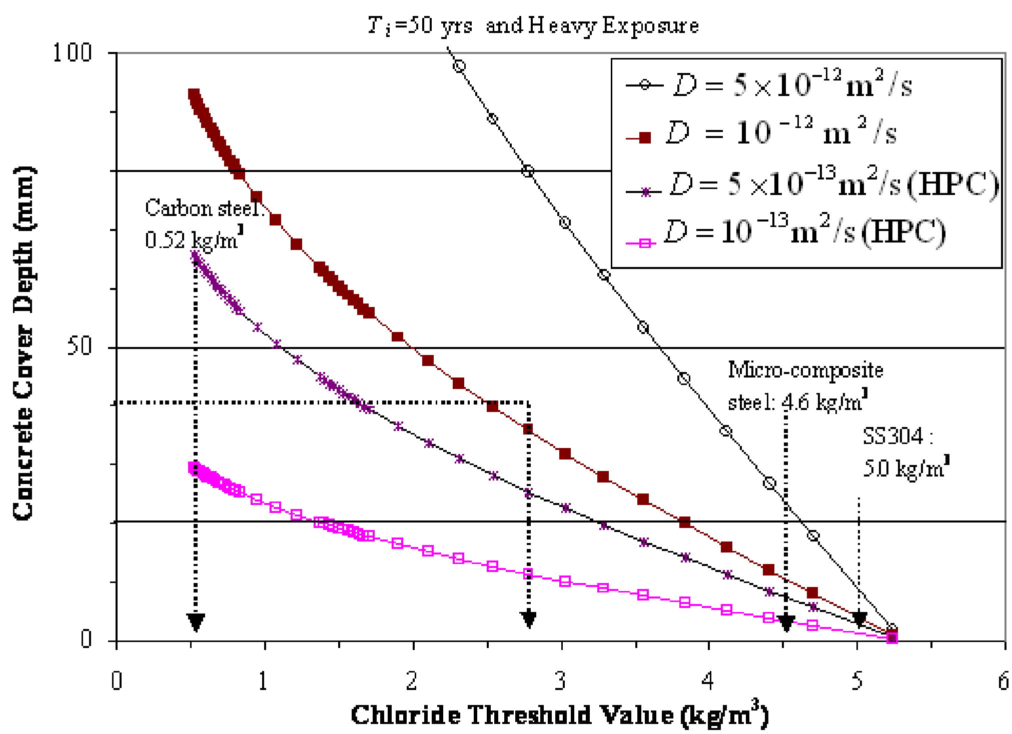

Figure 4: Variations of chloride threshold with concrete cover for different reinforcing steels and concrete types for a design life of 50 years 197

197 Zhang, J., Lounis, Z., “Sensitivity analysis of simplified diffusion-based corrosion initiation model of concrete structures exposed to chlorides”, Cement and Concrete Research. 36, 2006. pp 1312–1323.

Several studies showed that the highest corrosion rate was reached by the weld bead owing to the largest increase in the amount of nanocarbides, lesser coarsening and the presence of corroding products with higher brittleness and porosity[198]. The study of the corrosion products from the welded zone showed the presence of oxide and sulphur of iron, which are very brittle and porous [199]. The welding process produces a heat affected zone (HAZ) in which the steel reinforcement goes through a metallurgical change, depending on the welding method and chemical composition of the steel. This in turn leads to changes in the microstructure of the steel, mechanical properties such as strength and ductility, and corrosion performance. The cooling rate as part of the welding process can also create residual stresses in the steel reinforcement, which reduces both the fatigue and corrosion resistance. Welds with under-cut would have higher stress concentration and lower cross sectional area.

198 Nikolaou J et al. "Mechanical properties of lap-welded reinforcing steel bars for repairing damaged reinforced concrete structures." Materials and Structures, 37, 2004, pp 698-706

199 Apostolopoulos et al., "The impact of corrosion on the mechanical behavior of welded splices of reinforcing steel." Journal of materials engineering and performances, 17 , 2008, pp 70-79

The yield and ultimate strengths of the reinforcing steel could increase with welding[200]. The steel microstructure changes from "Ferrite" to "Martensite" in the heat affected zone and the latter is always stronger. However, the steel elongation at the ultimate stress can be reduced by up to 73%[201]. The corrosion of the reinforcement could results in further degradation in mechanical properties of the welded zone, specifically: (i) severe reduction in the strength; and (ii) elongation at the ultimate strength can be reduced by up to 50%[202].

If a high number of tack welded stirrups are exposed to a corrosive environment in the high shear zones, then the safety of the girders can be affected mainly by reduction in the shear capacity, especially if these tack welded stirrups are adjacent to each other. The corrosion resistance to chloride attack and service life can be further reduced due to: (i) premature cracks in the concrete cover, which facilitate the penetration of chlorides (see CH2MHill observations[203]); and (ii) brittle failure of the steel reinforcement by stress corrosion cracking, if the stress in the steel is close to the yield strength

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200 Nikolaou J et al. "Mechanical properties of lap-welded reinforcing steel bars or repairing damaged reinforced concrete structures." Materials and Structures, 37, 2004, pp 698-706.

201 *Ibid*.

202 Apostolopoulos et al. "The impact of corrosion on the mechanical behavior of welded splices of reinforcing steel." Journal of materials engineering and performances, 17, 2008, pp. 70-79.

203 CH2MHill letter on Aug, 28, 2013: Tunnels T2, T3, T5 and T7 NU Girders – Field Observations on girder End Cracks and Prestressing Strand Misalignment.

(a progressive deterioration scenario is possible given the large number and close spacing of the tack welds).

From the structural design point of view and to accommodate the required fire resistance, adequate concrete cover is provided. Hence, it is reasonable to assume that the original design can provide an acceptable durability. CH2MHill indicated that their engineer observed thru horizontal and inclined cracks cutting through the width of the web (see CH2MHill Report[204]). The durability of the girders can be affected if the issues identified by CH2MHill with the concrete are not mitigated early in the life of the structure. Implementation of an effective asset management plan with good maintenance and prompt repair and rehabilitation of deteriorated girders/sections is critically important in achieving a design life of 75 years.

Tack Welding Impact on Fatigue Strength

CAN/CSA S6-06 and many international codes restrict the use of tack welding to authority pre-approval mainly for its effect on fatigue strength when used in structural reinforcement. Reference to some of the international codes has been provided in the earlier sections. Some additional codes are

[204] CH2MHill letter on Aug, 28, 2013: Tunnels T2, T3, T5 and T7 NU Girders – Field Observations on girder End Cracks and Prestressing Strand Misalignment.

referenced here to stress the point. The Arizona Department of Transportation[205] indicates in their construction manual that tack welding of reinforcing steel will not be permitted unless approved in writing by the Resident Engineer. Similarly, the Missouri Department of Transportation provides more details on the approval procedure of tack welding: "No inspection will be conducted until the plant inspector has received a copy of the approved shop drawings. Prior to making shop drawings, the contractor shall submit in writing for approval of the engineer any proposed tack welding in lieu of tying of the reinforcing bars of prestressed members. If approved by the engineer, the location of tack welding of reinforcing bars shall be shown on the shop drawings submitted for approval" [206].

The Australian Standards[207] state that "pre-qualification tests are required for the use of locational tack welds. This will entail tensile and bend testing of at least two bar sizes for all fabricators of reinforcing steel cages". The Australian Standards also restrict the locational tack welds to be only "used where they will not be subjected to lifting stresses and they are assumed to have no quantifiable structural performance". These documents as well as others state

[205] Arizona Department of Transportation, USA. Construction Manual. 2005.
[206] Missouri Department of Transportation. Practical Design Manual. Section 1029: Fabricating Prestressed Concrete Members for Bridges. 2013.
[207] AS 1554.3. Structural steel welding, Part 3: Welding of reinforcing steel. 2002 (updated 2007).

very clearly the need for preapproval of tack welding when used to join rebars to ensure its use on "non-structural" reinforcement.

Several studies offer plenty of evidence that welds cause reduction in structural performance, specifically fatigue strength. None of the papers recommend weld without reservations. Amon, et al. (2007) [208] showed that welds done in a controlled factory environment reduce fatigue life of weld-able steel. The authors state that when welded wire rebars (WWRs) are used for this purpose, the cross wires (that are welded to reinforcement in the primary shear direction) "are only located in the WWR in the top and bottom flanges so the welds are away from the high-stress zones". Tack welds used in the girders assembled in Freyssinet fabrication facility are vulnerable to fatigue-related problems, especially if they are located in the high shear stress zones.

Pincheira, et al. (1989) [209] carried out tests on large size girders to evaluate the performance of WWR shear reinforcement against normal stirrup shear reinforcement. They concluded "premature fracture of the vertical wires at the welded intersections reduced the ultimate strength of the member in

[208] Amorn, W., Bowers, J., Girgis, A., "Fatigue of deformed welded-wire reinforcement", PIC Journal, Jan-Feb, 2007.
[209] Pincheira, J.A., Rizkalla, S.H., Attiogbe, E.K., "Performance of welded wire fabric as shear reinforcement under cyclic loading", ACI Structural Journal, V 86. No.6. pp. 728-735.

comparison to that of the beams reinforced with conventional stirrups". The weld that caused a reduction in strength was factory-weld. The tack weld, especially when its quality and location are unknown will not perform as well as a factory-weld.

Possible reduction in fatigue strength can be due to: (i) existence of micro-cracks in the welded area due to the cooling rate in tack-welding process; (ii) residual stresses; and (iii) two-dimensional stress state that could be developed when the two joined rebars are stressed or when the stress in one of them exceeds the yield strength.

<u>Summary:</u>

1. The tack welds in the girders in question were not pre-approved by MTO.

2. The quality and the locations of tack welds are unknown.

3. Deep cracks are observed in the precast prestressed concrete girders in high shear stress zones where tack welds are used in stirrups.

4. The analyses presented by ProjectCo claim that even when some of the stirrups are assumed lost, strength is still sufficient[210,211,212,213]. These analyses are based on: (i) assuming uniform distribution of tack welding; and (ii) the shear distribution on an equivalent rectangular flange and not the actual variable flange of the NU Girders section profile. No information has been presented on the durability of the girders.

5. The tests presented by ProjectCo show that tack welds did not reduce strength of the rebars. This information, although encouraging, does not address the concerns about durability and ductility.

6. The quality of the fabrication and the existence of cracks in critical zones could lead to a reduction in the durability and fatigue strength.

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210 E.Construct letters on February, 18, 2013 and May, 15, 2013. ProjectCo folder: technical Reports/ E-C_Construct_Reports.

211 HMM report: August-16_T2T3T5T7_revised-sensitivity_tables_fire_case_B.pdf. ProjectCo folder: technical Reports/HMM_Reports.

212 M.P. Collins & Associates Inc. Evaluation of shear capacity of pretensioned prestressed concerete bridge girders with tack welded stirrups. August, 18, 2013. ProjectCo. Folder: technical Reports/Michael_Collins_Reports

213 FHECOR – Ingeniers Consultores. Evaluation of shear capacity of pretensioned prestressed concerete bridge girders with tack welded stirrups. August, 27, 2013.

CONCLUSIONS AND RECOMMENDATIONS

Safety is never a certainty. It is both an aspirational goal and a calculated risk. Similarly, nothing is forever, and durability is no exception. The best engineering practice, with perfect compliance in its implementation, nonetheless provides for a "*factor of safety and probability of failure*" as a predictive tool to address the realities of any engineered structure.

The *raison d'être* for regulations, codes and standards with respect to the fabrication of prestressed concrete girders is to ensure a level of safety and durability. Non-compliance would not necessarily mean that the girders are unsafe, or that they suffer from the prospect of a short life span.

However, once the girders have been fabricated, and in some cases installed, the only way to know anything about their safety and durability, albeit imperfectly, would be to embark upon the deconstructive testing of samples, and then to extrapolate from the results of those tests. That approach is obviously not perfect; and, in this case, put the IER Committee at a disadvantage of having to evaluate the girders' safety and durability in circumstances where there is uncertainty arising out of the fact that they may have been fabricated without full and proper compliance with all regulations,

codes and standards, with tack welding not approved by a regulatory authority (i.e., MTO), in a non-CSA- certified plant, and by welders whose own certification credentials and workmanship are subject to review.

All of this creates a difficult spectre of uncertainty that must be rationalized after the fact.

By way of analogy, a traditional "legal" approach would endeavor to put a party in the same position as he/she would have been in, had the conduct in question not occurred. Similarly, to the extent that there may *not* have been full compliance with all applicable regulations, codes and standards in connection with the fabrication of the 500 Freyssinet girders, the ultimate beneficiary of the Parkway project, namely the Province of Ontario, should be put in the same position as it would have been in, had there been proper and full compliance.

That is to say, the IER considered whether the factor of safety and probability of failure, which should have been achieved with compliance, can now be achieved after the fact with the level of scrutiny which the IER brought to bear on the fabrication of the prestressed concrete girders.

<u>THE IER COMMITTEE'S CONCLUSIONS</u>:

<u>Question</u>: Can the IER Committee confirm that the 500 Freyssinet girders are safe and durable without any remedial measures?

<u>Answer</u>: The IER Committee unanimously says "No".

<u>Question</u>: Is the IER Committee of the view that the 500 Freyssinet girders could be made safe and durable with remedial measures?

<u>Answer</u>: The IER Committee unanimously says "Perhaps". The 500 Freyssinet girders would only be salvageable using muscular remedial measures.

It is impossible for remedial measures to result in legal compliance retroactively to achieve the minimum standard of safety and durability achieved by compliance with all applicable regulations, codes and standards in the fabrication of the 500 Freyssinet girders.

That is, if Freyssinet observed all legal requirements religiously in the fabrication of these girders, it would have achieved the lowest acceptable risk of failure. Where there is non-compliance, the risk of failure increases. It is impossible for the IER Committee to assess the magnitude of that risk, with

any measure of professional confidence, after the fact of non-compliance, especially when the information about things like the quality of tack welds, their frequency and their locations, are unknown.

Accordingly, the IER Committee is unanimous that, unless there is a satisfactory remediation protocol, it is an irresistible conclusion that the 500 girders fabricated by Freyssinet are not acceptable for use in the Rt. Hon. Herb Gray Parkway.

During the IER process, the project's stakeholders had the opportunity to make full presentations regarding the safety, durability and compliance with respect to the 500 Freyssinet girders, including a consideration of possible remedial measures on a contingency basis.

The IER Committee has now had the benefit of extensive consultation and dialogue, further research, and the observations associated with aspects of deconstructive testing which were not available earlier.

Based on the information received so far, it is the opinion of the IER Committee that the girders do not meet the requirements of the applicable regulations, codes and standards. With various violations in the design and construction requirements and the uncertainties in the construction of these

girders, the IER can not unequivocally opine that the girders are safe and durable. In fact, there is evidence that safety and durability of the girders have been compromised.

The IER Committee has therefore considered and now recommends two options, as follows:

OPTION A:

As stated earlier, it is not possible to have legal compliance of the 500 girders retroactively with all applicable regulations, codes and standards. To achieve this, the only option is to replace deficient and non-compliant girders with new ones that are constructed in accordance with all the applicable requirements for design and construction.

OPTION B:

Existing non-compliant girders may be salvaged for service through the steps listed below. In the development of these steps, IER Committee considered the recent test results, some of which were found to be encouraging although they did not address all the concerns related to durability of the girders:

1. Survey the girders for visible deficiencies and signs of distress. Measure the deflection profile when they are supported at the ends. This step is aimed at identifying the girders that have a large or unusual deflection profile and may not be suitable for use.

2. Of the girders selected for use, strengthen girders that are deemed deficient in shear using a mechanism that reduces stress in the internal stirrups to address the fatigue problem that may be caused by tack welds. Results from the ongoing tests should be considered to determine the extent of strengthening. The spans of the girders where stirrups are used at large spacing (600 mm in some cases) are especially vulnerable if the stirrups are compromised due to tack welding and do not perform as intended.

3. The strengthening mechanism discussed in paragraph number 2 above must meet the required fire-rating.

4. Tack welding is known to increase the risk of corrosion of steel. The corrosion rate in the welded stirrups should be monitored at selected critical locations and steps taken to mitigate the adverse effects of corrosion.

5. In the tests carried out by ProjectCo, the pre-stressing tendons have been reported to be misaligned. This may result in under-stressing of the girders, excessive stress concentration in the end zones, pre-mature cracking and excessive deflection. Steps must be taken to address these issues.

6. Since the girders have been found to be deficient with respect to compliance with the design and construction requirements that will compromise their strength and durability, robust continuous structural health monitoring is required to ensure their performance in the short and long terms. In addition, an enhanced inspection regime by independent trained professionals is required to mitigate possible hazards arising from the deficiencies of the girders.

7. With respect to T2, T3, T5 and T7, if any girder should exhibit shear cracking before the Expiry Date, as defined and set out in the Project Agreement, such girder should be replaced by ProjectCo at its sole cost and expense.

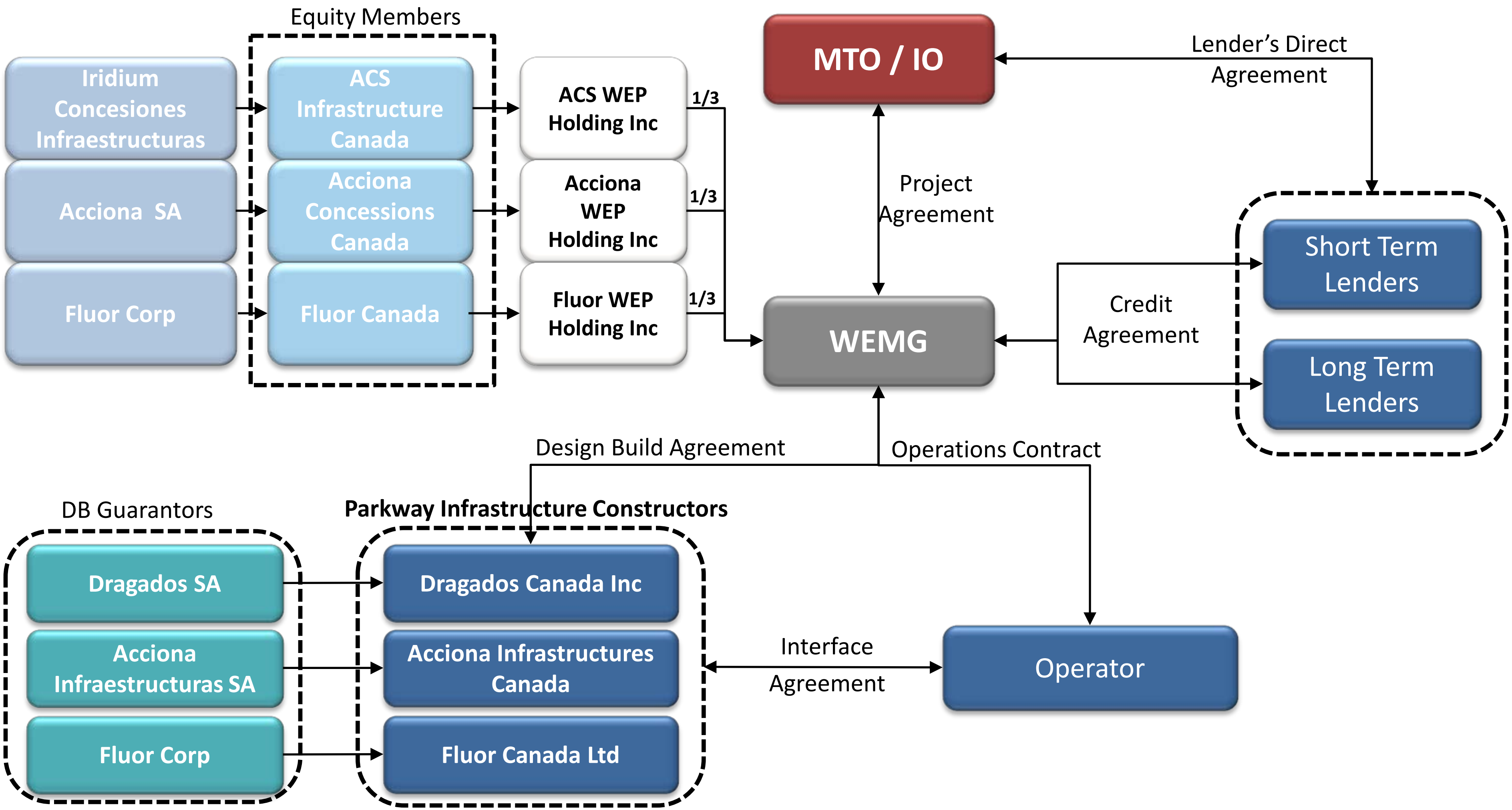
In coming to these conclusions and making these recommendations, the IER Committee is mindful of the potential serious financial implications, time

delays, and impacts associated with the issues under review, and the passion for the respective positions taken by the presenters who have provided transparency and cooperation in the context of a full and frank dialogue.

Nevertheless, persons who travel this road, and the Province of Ontario which owns it, are entitled, at least in our professional opinion, to expect nothing less.

Schedule A

WEMG - Organization Structure



Ontario

BACKGROUNDER

Ministry of Transportation

Parkway Review Committee

August 12, 2013

The government has retained leading experts to review concerns about certain concrete girders installed on the Rt. Hon. Herb Gray Parkway.

Review Committee Chair

The chair of the independent expert review is Harvey J. Kirsh, a recognized authority in construction law. Mr. Kirsh has 40 years of experience in the litigation, arbitration and mediation of complex construction claims and disputes arising out of significant infrastructure, energy, resource, industrial, commercial, and institutional projects, both domestically and internationally. He was the founding president of the Canadian College of Construction Lawyers, and is a fellow of both the American College of Construction Lawyers and the College of Commercial Arbitrators. Designated as a chartered arbitrator since 1984, he is a member of the Global Engineering and Construction Group of JAMS, the largest private provider of alternative dispute resolution services in the world. He is counsel to the Toronto construction law firm Glaholt LLP and has been certified by the Law Society of Upper Canada as a “Specialist in Construction Law”.

Review Committee Members

- Dr. Husham Almansour is a research associate with the National Research Council Institute for Research in Construction and an adjunct professor in structural engineering at the Ottawa-Carleton Institute of Civil Engineering. Dr. Almansour has 25 years of experience in structural design, modeling and testing, with focus on bridge structures.

- Carlos Laborde-Basto is an engineer and owner of Laborde and Associates. During his career, Mr. Laborde-Basto has supported project teams, conducted structure condition surveys and evaluations, and provided direction for rehabilitation and special studies on structures. He has been involved as a specialist and project manager in numerous provincial and municipal road and bridge projects.

- Dr. Saeed Mirza is Professor Emeritus at McGill University and is an internationally recognized authority in non-linear structural concrete analysis and design, as well as the design, management and assessment of sustainable civil infrastructure. Dr. Mirza is the recipient of several university, national and international awards for outstanding teaching, research and scholarship, and has made significant worldwide contributions to the development and practice of civil and structural engineering.

- Dr. Shamim Sheikh is a professor of civil engineering at the University of Toronto. Among his many awards is the American Concrete Institute Structural Research Award for outstanding contributions to the application of structural engineering research and for notable achievement in research in structural engineering. Currently, Dr. Sheikh chairs Committee S16 of the Canadian Highway Bridge Design Code (CHBDC) on fibre-reinforced structures and is a member of the CHBDC Committee.

- Dr. Dagmar Svecova is a professor in the department of civil engineering at the University of Manitoba, with research interests in the field of structural engineering including reinforced and prestressed concrete structures. Dr. Svecova is a member of the American Concrete Institute and the Canadian Society of Civil Engineers and is director of the Intelligent Sensing for Innovative Structures Canada Resource Centre.

Independent Expert Review of Certain Girders Manufactured for the Rt. Hon. Herb Gray Parkway

Terms of Reference

Table of Contents

1. Context

The Rt. Hon. Herb Gray Parkway (Parkway), formerly the Windsor-Essex Parkway, is a $1.4 billion highway infrastructure project under construction in the municipalities of Windsor, LaSalle, and Tecumseh. This is a 'once-in-a-generation' undertaking that will improve traffic flow at Canada's premier trade gateway and is unprecedented in its community enhancement and environmental features for a highway project in Ontario.

The Rt. Hon. Herb Gray Parkway spans an 11-kilometre corridor. It includes four essential components:

- a six-lane below-grade freeway which is an extension of Highway 401
- a four-lane at-grade service road network which is an extension of Highway 3
- 11 tunnel sections that range from 120 to 240 metres in length covering 1.8 kilometres of the freeway and/or service road network
- 300 acres of green space which will include 20 kilometres of recreational trails, ecological restoration sites and thousands of new native tree and vegetation.

Upon completion, the Parkway will provide the safe and efficient movement of people and goods to and from a proposed new Canadian inspection plaza and international bridge, separate local and international traffic, and eliminate stop-and-go traffic in residential areas.

Construction started in 2011 and it is estimated that the project is generating approximately 12,000 jobs by creating business opportunities, attracting new investment, and supporting existing industry. The majority of these jobs are in the Windsor-Essex region. It is anticipated that the Parkway will be open to traffic in late 2014.

The Parkway is being delivered by Infrastructure Ontario (IO) with the support of the Ministry of Transportation (MTO) through an Alternative Financing and Procurement model under a design, build, finance and maintain (DBFM) contract with the Windsor Essex Mobility Group (WEMG) and their joint venture partner, Parkway Infrastructure Constructors (PIC).

A potential issue emerged regarding the safety and durability of certain girders on the Rt. Hon. Herb Gray Parkway. This Independent Expert Review has been established to assess and make recommendations with respect to this issue.

2. Purpose of Independent Expert Review

2.1. Membership

The Independent Expert Review shall have at least three members and a maximum of six members.

2.2. Member Selection

The Deputy Minister of Transportation shall appoint a Chair for the Independent Expert Review. The Deputy Minister of Transportation in consultation with the Chair will appoint independent experts in civil/structural engineering and associated construction issues as other members of the Independent Expert Review.

2.3. Mandate

The Independent Expert Review will undertake a thorough and comprehensive review in order to fulfill its obligations. The Independent Expert Review will review the engineering and construction issues related to the fabrication and installation of certain girders.

The Independent Expert Review shall have complete operational and intellectual independence in the performance of its mandate and preparation of its report. The independence of the Independent Expert Review will be fostered through independent research and consultations and dialogue among interested parties.

The Independent Expert Review will strive for consensus in all matters.

The purpose of the Independent Expert Review is to provide independent advice to the Minister of Transportation. The Independent Expert Review shall perform its duties without making any findings of fault in relation to misconduct, or expressing any conclusions or recommendations regarding issues that may arise in a potential legal proceeding. The Independent Expert Review will be reporting to the Deputy Minister of Transportation and MTO's Chief Engineer based on their assessment of:

i. The safety of these girders;
ii. Performance of these girders, related to their quality and durability;
iii. Compliance.

With respect to the above, the Independent Expert Review shall consider:

i. The safety of these girders

- Are the girders suitable for the expected loads and conditions?
- If not, are there specific concerns and are any remedial measures required that could ensure safety?

ii. Performance of these girders, related to their quality and durability

- Will the girders meet quality and durability performance requirements?
- Are any remedial measures required to ensure performance?

iii. Compliance

- Are these girders compliant with any applicable act and regulations?
- Do the girders meet all the requirements of the Canadian Highway Bridge Design Code (CHBDC) recognizing their intended use in the project?

In carrying out the mandate, the Chair of the Independent Expert Review may request information from staff members of IO, MTO and the Ministry of Infrastructure, and any consultants or contractors whom the Chair and Review members may see fit to interview.

IO, MTO and the Ministry of Infrastructure will assist the Independent Expert Review to the fullest extent possible, including procuring any documents requested by the Independent Expert Review in a timely manner, so that it may carry out its duties.

The Independent Expert Review will rely on the cooperation of any other individuals contacted, in that the Independent Expert Review does not have the legal authority to either compel individuals to provide information or produce documents.

2.4. Legal Considerations

Legal advice relating to certain girders and associated issues will be made available to the Independent Expert Review through legal counsel retained by the Ministry of the Attorney General pursuant to the *Corporate Operating Policy on Acquiring and Using Legal* Services of the Ministry of the Attorney General. The Independent Expert Review shall take the legal advice into consideration when reporting to the Deputy Minister of Transportation and MTO's Chief Engineer.

2.5. Term

Members will sit for a thirty (30) day period to complete the mandate detailed in section 2.3. Should the members feel it appropriate to sit beyond the term for an additional period, a request can be made to the Deputy Minister of Transportation.

2.6. Notice

If a member plans to resign from the Independent Expert Review prior to the end of his/her term, then the member must provide written notice to the Chair of the Independent Expert Review prior to his/her resignation date.

2.7. Meetings

The Independent Expert Review will convene as needed and as directed by the Chair.

The format of the meetings (face-to-face, teleconference, etc.) will be at the discretion of the Chair as necessary to undertake the review in an effective and comprehensive manner. Face-to-face meetings will take place in Toronto, or in another location as determined by the Chair.

A senior government employee(s) may attend meetings of the Independent Expert Review, at the invitation of the Chair, to provide support as may be needed and respond to questions from the members that may arise.

2.8. Remuneration

Rates for Services

Members of the Independent Expert Review will be paid in accordance with the daily rates, process, terms, and definitions specified in each letter of appointment addressed to each individual member.

Reimbursement of Allowable Expenses

Members of the Independent Expert Review are eligible to receive reimbursement for allowable expenses incurred in the performance of their responsibilities, subject to applicable government policies.

2.9. Support

If required, the Independent Expert Review will be provided with clerical and administrative support services.

2.10. Transparency

It is intended that the process and results of the Independent Expert Review are to be transparent, provided that (a) all legal advice, (b) all deliberations of the members of the Independent Expert Review, (c) any document of information provided by WEMG/PIC which is expressly identified as confidential or commercially sensitive, shall be confidential and not be divulged, except as may be required by law.

2.11. Conflict of Interest

Members shall avoid any actual or potential conflicts of interest in relation to their responsibilities on behalf of the Independent Expert Review, and shall immediately declare any potential or perceived conflict of interest. Members cannot use confidential information obtained as a result of their appointment as members to the Independent Expert Review for personal benefit.

3. Independent Expert Review Responsibilities

3.1. Responsibilities of the Chair

In addition to all the responsibilities of a member (as outlined below), the Chair is responsible for the following:

i. coordinating, overseeing and chairing meetings;
ii. leading and coordinating the work of the Independent Expert Review;
iii. facilitating discussion among members; and
iv. leading the preparation and delivery of the findings of the Independent Expert Review to the Deputy Minister of Transportation and MTO's Chief Engineer.

3.2. Responsibilities of Members

Members of the Independent Expert Review have a responsibility to offer their independent and objective advice to the Deputy Minister of Transportation and MTO's Chief Engineer related to their mandate. Other responsibilities include:

i. being available and prepared to participate in meetings of the Independent Expert Review;
ii. being available and prepared to attend meetings and consultations related to the Independent Expert Review's mandate;
iii. considering information that is relevant to the Independent Expert Review's mandate;
iv. effectively contributing to discussions of the Independent Expert Review and the development of the final report; and
v. notifying the Chair of any changes in the status of their affiliations and interests relevant to the Independent Expert Review's mandate.

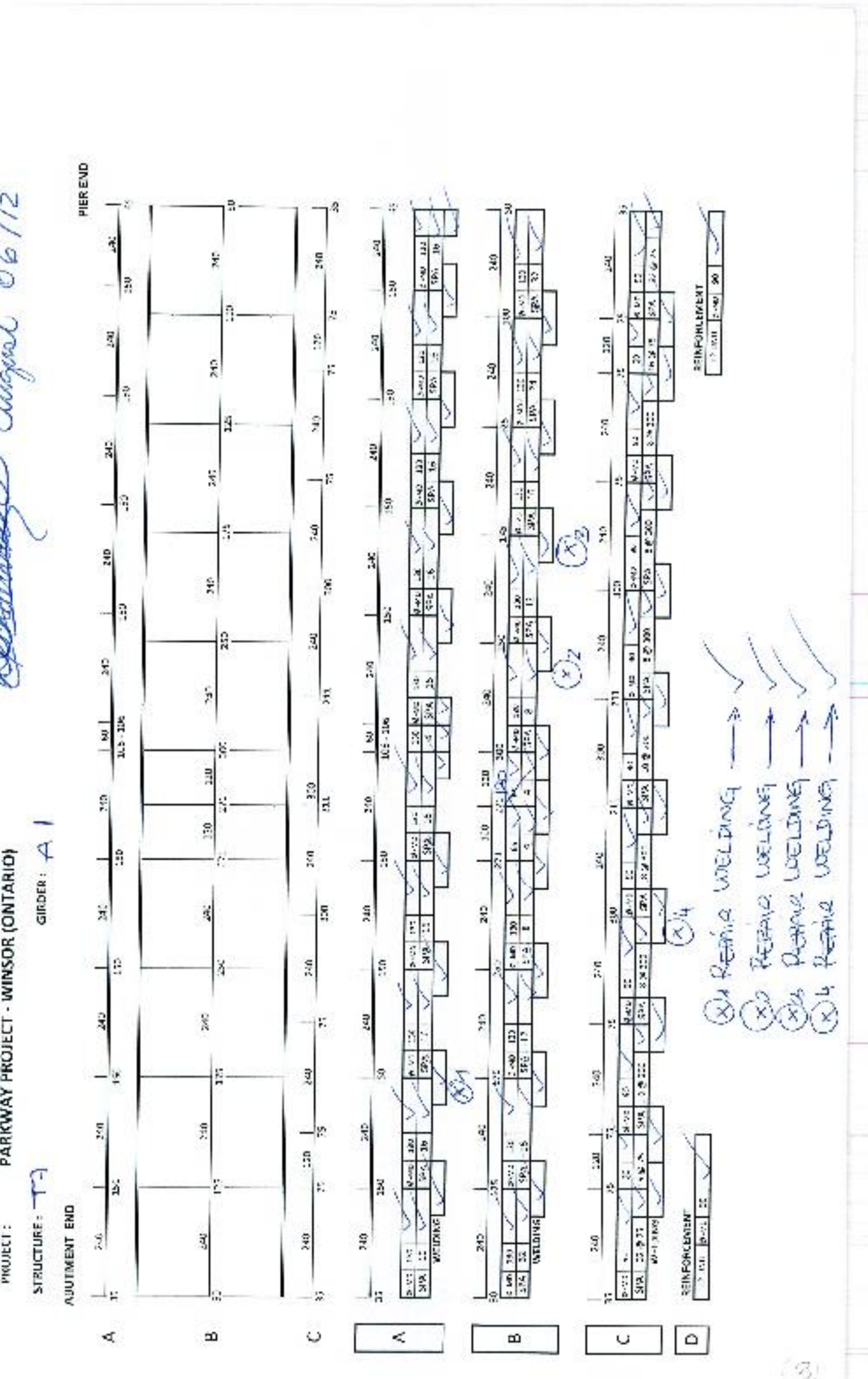
3.3. Reporting Requirements

The Independent Expert Review shall submit a report to the Deputy Minister of Transportation on the findings by the end of August 2013 subject to any extension which may be granted in writing by the Deputy Minister of Transportation. The report shall be presented by the Independent Expert Review to the Deputy Minister of Transportation and MTO's Chief Engineer.

3.4. Recommendations of the Independent Expert Review

Given their findings the Independent Expert Review will be clear in its recommendations on what to do with these girders. In making their recommendations, the Independent Expert Review will apply professional engineering practices and standards.

Schedule D


TIERRA ARMADA
FREYSSINET
PROJECT : PARKWAY PROJECT - WINSOR (ONTARIO)
STRUCTURE : T-7
GIRDER : A 1
ABUTMENT END
PIER END
August 06/12
WELDING
REINFORCEMENT
X1 Repair WELDING
X2 Repair WELDING
X3 Repair WELDING
X4 Repair WELDING

GS Inspection Consultants, Inc. A1

2090 North Talbot Road, Unit B, Windsor, ON N9A 6J3/ Ph: 519 -737-9119 / Fax: 519 -737-9163

DAILY INSPECTION REPORT

Client: Tierra Armada			
Project: Reinforcing Structure for Concrete Beams			
Location: Van De Hogan		**Inspector:** Scott Griffin / J. Stewart	
Project No:	**Report No:** 1	**Page No:** 1 of 3	**Date:** 2012-8-2

Item	Observations:	Status	Corrected
1.0	A visual welding inspection was performed on the first 3 reinforcing cages for the concrete beams. This inspection took place at Van De Hogan Cartage yard in Windsor, Ontario. The weather conditions at the time of inspection are sunny and bright, 26°C, no precipitation.		
1.1	Inspection Codes and Drawings		
1.2	CSA W186-M1990 (R2012)		
1.3	Drawings # 3A, 3B, 3C, 4, 5, 1 and 2 for Villa Borgchese Tunnel T-7		
1.4	Inspection Results		
1.5	The flux-core welding process was being used. The wire or electrode is Fabshield 21B by Hobart, E491T-11-H8, 1.2mm Ø	A	
1.6	The wire mesh / reinforcing bars material test reports and compliance are being forwarded to the inspector at this time.	I	

Comments:

A Acceptable to Code **U** Unacceptable to Code **I** Incomplete

CWB 43833

Signature of Inspector, Inspector Certification

Level II

Inspection Supervisor, Supervisor Certification

QUALITY VERIFICATION ENGINEER SERVICES

Special Provision No. 199S48 December 2005

Definitions

Certificate of Conformance: means a document issued by the Quality Verification Engineer confirming that the specified components of the Work are in General Conformance with the requirements of the Contract Documents.

General Conformance: means that, in the opinion of a professional engineer, the standard of construction work fulfills the essential requirements of the Contract Documents, and has been done in accordance with normally accepted industry standards, and will perform its intended function.

Interim Inspection: means an inspection confirming that the specified components of the Work are in General Conformance with the Contract Documents and a written permission issued by the Quality Verification Engineer to the Contractor to proceed to the next stage of the Work.

Quality Verification Engineer: means an Engineer qualified to provide the quality verification engineer services specified in the Contract Documents.

General

The Contractor shall employ or retain one or more professional engineers to provide the services of a Quality Verification Engineer (QVE). The Contractor shall obtain the written consent of the Owner before retaining a professional engineer who provided professional services to the Owner for the project.

The Contractor shall advise the Contract Administrator of the name of the QVE before the QVE provides services to the Contractor.

The QVE shall issue Certificates of Conformance, as specified in the Contract Documents, by completing Form PHCC-822 “Certificate of Conformance”. The QVE shall also issue written permission to proceed to the next stage of the Work following an Interim Inspection, as specified in the Contract Documents. A Certificate of Conformance shall be issued by one QVE who shall be responsible for all Interim Inspections of Work covered by the Certificate of Conformance. The Certificate of Conformance shall include the time, date and components inspected in all Interim Inspections. Where a QVE is unavailable to complete all the Interim Inspections that are specified, the QVE shall issue a Certificate of Conformance covering the Interim Inspections completed to date. The second QVE shall issue a Certificate of Conformance

covering the subsequent Interim Inspections for which the second QVE is responsible. In this event, the Contractor shall ensure that the Certificates cover all required inspections and shall submit them at the same time.

The QVE shall not delegate any activity that the Contract Documents require the QVE to “witness”. For all other activities, the QVE may delegate the function to another person where it is consistent with prudent engineering practice to do so, and the function is performed under the supervision of the QVE. The process prescribed in this Special Provision for correcting components of the Work not in General Conformance with the Contract Documents shall apply unless other remedies are prescribed elsewhere in

the contract documents.

December 2005 Page 1 of 2 SSP199S48

December 2005 Page 2 of 2 SSP199S48

Construction

The Contractor shall submit Certificates of Conformance, with reference to the applicable Working Drawings and other Contract Documents, to the Contract

Administrator at the milestones identified in the Contract Documents and prior to commencing subsequent stages of the work. The Certificate of

Conformance shall be submitted within 48 hours of completing the Work described in the Certificate of Conformance unless a different period is specified elsewhere in the Contract Documents. Where Interim

Inspections are specified, the Contractor shall not proceed until written permission is received from the QVE. A copy of the written permission shall be made available to the Contract Administrator upon request.

The QVE shall seal, sign and date Certificates of Conformance indicating that construction of the Work is in General Conformance with the stamped Working Drawings and the requirements of the Contract Documents. No conditions or limitations shall form part of the Certificate of Conformance or the written permission to proceed following an Interim Inspection. Any amendments to the Contract Documents accepted by the Owner, and related to the Certificate of Conformance, shall be appended.

Non-Conforming Work by the Contractor

If the QVE is prevented from issuing a written permission following an Interim Inspection, or a Certificate of Conformance, because of lack of clarity

of the Contract Documents, the QVE shall seek clarification of the requirements from the Contract Administrator. If components of the Work have aspects that are not in General Conformance with the Contract

Documents, the Contractor may propose an amendment to the Contract Documents. The Contractor shall, under the seal and signature of the QVE, provide the Contract Administrator with an itemized, detailed description of all aspects within the scope of the Certificate of Conformance that are not in General Conformance with the Contract Documents. The Contractor shall also, under the seal and signature of a professional engineer (who may or may not also be the QVE), provide to the Contract Administrator recommendations for an amendment to the Contract Documents that will deliver the functionality of the original Contract Documents. The proposal for an amendment to the Contract Documents differs from a change proposal. A proposal for an amendment to the Contract Documents occurs after the work has been carried out, and the Work does not conform to the Contract Documents.

The Contract Administrator will:

i) reject the proposed amendment, and require the Contractor to take whatever remedial measures necessary to achieve a Certificate of Conformance based on the original Contract Documents.

or

ii) Accept the proposed amendment, but negotiate a credit from the Contractor where the Owner deems that the amendment does not deliver the same quality or performance as the Work specified in the Contract Documents, and require the Contractor to submit a Certificate of

Conformance for the work with the accepted amendment attached.

or

iii) Accept the proposed amendment and require the Contractor to submit a Certificate of Conformance for the work with the accepted amendment attached.